DAIRY CATTLE MANAGEMENT

Principles and Applications

REINHOLD BOOKS IN AGRICULTURAL SCIENCE

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CONSULTING EDITOR'S STATEMENT

Dairymen today are hard pressed to cope with the rapid outdating of dairy management methods that has accompanied the present scientific-technological advance There has been an increasing demand for a truly up-to-date book dealing with fundamentals—a book flexible enough to provide practical solutions for a bewildering array of management problems In this respect, James M Wing's "Dairy Cattle Management Principles and Applications" is a rare achievement that will be invaluable to students, professional managers, and research workers

In our growing economy, a knowledge of the principles that must be applied to obtain maximum milk production is of vital importance Dr Wing sets forth these principles in a logical manner, and demonstrates each relevant application clearly The roles of breeding, physiology of the animal, response to environment, health of the animal, and feeding must all be brought into harmony in order to achieve quality and quantity of production The author carefully develops these and other important areas in such a way that the student will find the book stimulating and thought provoking The teacher and dairyman will welcome the informative and modern approach

"Dairy Cattle Management Principles and Applications" is actually a book within a book As a special feature, Dr Wing has placed at the end of his book a Ready Reference Handbook, which serves as a strategically positioned practical manual In the Ready Reference Handbook, a number of frequently used general guides for the dairyman have been gathered together for ready reference I like the care with which Dr Wing has cross referenced these general guides to those discussions in the text which make possible their intelligent evaluation and use

Reinhold is proud to present James M Wing's "Dairy Cattle Management Principles and Applications" as the latest addition to Reinhold Books in Agricultural Science, a series dedicated to the clear enunciation of the latest advances in agriculture and the unifying principles that make them meaningful

J Ritchie Cowan

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PREFACE

AGRICULTURE HAS FELT THE EFFECTS OF THE NEW SCIENTIFIC-INDUSTRIAL revolution more quickly and intensely than business in general. The genetic quality of dairy cattle, economic structures, and general advancement in industries closely allied to the dairy business outdate many practices common less than a decade ago. Modern dairymen are frequently faced with problems having no precedent, and the fundamental approach has become mandatory. Consequently, drastic changes have been proposed for curricula in agriculture. Clearly, less emphasis is needed on *how* and more attention must be devoted to *why* things happen. Modern college courses are stressing principles, and in the field of dairy cattle management this trend has made all previous textbooks obsolete. Moreover, most modern reference books on the subject are lacking in sufficient flexibility and tend to prescribe applications too literally, without adequate evaluation of underlying scientific principles, the successful application of which makes the difference between superior and routine management.

The present book deals with animal fundamentals that can be employed to solve new problems as they arise. Thus it should be useful to students and to workers in dairying and in the businesses that serve the dairy and other animal industries. Although no attempt has been made to supply answers to all of today's problems, the applied material included is sufficiently generous to illuminate the practicality of the fundamental approach. The student is introduced to principles in the first chapter. Here new concepts of physiology and related sciences as well as classical examples are utilized to explain the response of the cow to her environment. Such topics as the general adaptation syndrome, homeostasis, stress, conditioned reflexes, and natural impulses are presented in Chapter 1 as a basis for subsequent material.

The dairy cow has achieved prominence in the world's economy largely because she is a ruminant. Therefore, ruminology is introduced in Chapter 2. Managerial principles concerning the development and maintenance of normal rumen structures and the proper flora and fauna quickly become familiar tools for the student, the important synthetic functions of the

rumen being emphasized throughout the book Modern concepts of feed evaluation and utilization also are presented early

The effects of weather upon the basic body reactions are discussed in relation to management practices Chapters 3 to 5 on thermal neutrality, radiation, conduction, and convection as influenced by nerves, body secretions, and the environment provide workable tools for reasoning out solutions to new problems

Lactation is developed in Chapter 6 as a physiological function, and various parts of the book show how principles that affect the body as a whole are involved in the production of milk The digestibility of feed including both the speed and thoroughness of the digestive process, the specific dynamic action, the weather, genetic merit, rumen functions, and body chemistry supplement the purely physiological discussion of milk secretion in the formulation of policies concerning milking management

It is well known that plants supply most of the feed for dairy cattle Since Chapter 7 stresses the physiology of living plants and the biochemical processes by which they are utilized and preserved, the student will learn how the application of soil and plant sciences affect the management of cattle Fertilizer practices, soil structures and textures, plant enzymes, sunlight, plant varieties, and various similar factors will thus become familiar considerations

The basis of sanitation and health management has been given prominence because the stress of today's high speed production frequently creates new problems in these areas Principles of animal adaptation, immunization, chemistry of cleaning, and sanitation all become tools for use in the formulation of management policies

Reproduction is shown to be one of the most serious problems in dairy cattle management Fundamental training on this subject is supplied mainly in Chapter 13, which is supported by the remainder of the book Principles can be applied to raising dairy calves quite easily, and a new approach is particularly important because mortality and the cost of herd replacements are still much higher than necessary

In this era of change, building designs must be flexible The principles discussed herein include consideration of such topics as automation, types of feed and other materials to be handled and stored, and ventilation It is shown how design of dairy structures can be based on physiological principles that apply to the comfort and productivity of the cows

Modern dairy business management can be founded on scientific principles dealing with fundamental reactions of the animal body Emphasis is given to these in the last chapter Although applications are more than adequate, the main purpose of this book is to supply students and workers

with tools for the formulation of their own policies in handling present and future problems, many of the latter being as yet unforseen

Bibliographical references and questions for review are given at the end of the text It is hoped that the Ready Reference Handbook (page 291) will prove to be a valuable aid to managers and students alike It contains *information that will be referred to frequently in the solution of management* problems and is an integral unit in itself, although it is carefully cross referenced to the text material

So many governmental and business organizations and individuals have contributed to this undertaking that listing them here would be impractical Attention will be called to various contributions in the body of the book The author is indebted especially to Dr C J Wilcox for his encouragement and counsel and to Mrs Helga O'Steen for secretarial assistance

INTRODUCTION

THE AMERICAN DAIRY INDUSTRY, WHICH APPEARS TO HAVE JUST COME OF age, may have difficulty adjusting to its new role in the economy However, dairying is an especially efficient means of utilizing crops and labor, and it undoubtedly will continue as one of our most vigorous agricultural businesses In most respects, American dairying is the most advanced in the world, as is indicated by the outstanding herds, the quality and variety of dairy products, the automated barns and plants, and the advanced methods of distribution and technology

Great value has been placed on the dietary qualities of milk and milk products in the pages of recorded history A few examples here will suffice As is well known, Columbus brought cattle on his second voyage, and early settlers of this continent prized dairy products enough to transport cattle long distances under the most adverse conditions The greatest consumption of dairy products has occurred among the more highly developed and prosperous people of the world, various authorities are, therefore, inclined to attribute much of the development of the human race to the use of milk and its products

While dairying is known to be one of the oldest of the agricultural business, most of the progress in the science of milk production has occurred during the last 100 years Giant strides in dairying accompanied the industrial revolution generally Dairying developed simultaneously with, and as a result of, such basic sciences as bacteriology, nutrition, quantitative genetics, physiology, and veterinary science, and with inventions which took processing from the home to the factory and made preservation and distribution of milk and milk products practical Hence, the efficiency of dairy production has followed a general increase in industrial efficiency

Approximately 15 per cent of American farm income is from milk The dairy industry supplies also about 35 per cent of the beef, and indications are that the demand for dairy beef will increase as meat technology advances Over 300,000 people are employed in the dairy industries, and the need for trained personnel is growing In addition, dairy products enjoy an envious acceptance because of their importance in the diet of infants, youth,

the infirm and the aged, as well as being staple foods for healthy adults Roughly 20 per cent of American food purchases are dairy products

Over 100 food elements have been identified in milk, and it is accepted generally that many still unidentified factors contribute further to its value In the diet of a teen-aged person, a quart of milk daily supplies about 82 per cent of the calcium needed, 63 per cent of the phosphorus, 83 per cent of the riboflavin, 30 per cent of the Vitamin A, 22 per cent of the thiamine, and 21 per cent of the calories, as well as the total requirement of Vitamin D The proteins of milk are of especially high quality For the average adult three glasses daily provide half the required methionine, cystine, and phenylalanine, and all required lysine, leucine, and isoleucine Americans consume about 30 per cent of their animal protein as dairy products Moreover, cottage cheese and dry milk are the least expensive sources of high quality protein on the American food market

Of course, the perishable nature of milk has posed a difficult problem Instant dry milk and concentrated products are now available Sterile canned milk with all of the characteristics of fresh milk has been processed experimentally and may be on the market shortly Such products will have indefinite shelf life and will tremendously increase the importance of dairy products to the average American family

As prices in general have increased so have those of dairy products, but at a considerably slower rate than other products because of the rapid advances of technology in the dairy industry A good way to measure efficiency of industries is to compare the value of products to the man-time spent in producing them Upon the basis of such calculations, it can be seen that almost half of this century's progress in dairying has occurred since World War II In gains per man, agriculture has gained 8 per cent annually since 1947 as compared to slightly over 2 per cent for nonfarm industries It is also significant that dairy cattle numbers have declined rapidly, though total production of dairy products has increased Thus part of the recent trend is an extension of our technological advance, methods, cattle, and equipment are being improved continually

This type of development is not unique to dairying In 1900, 37 5 per cent of the American workers were employed on farms as compared to about 10 per cent today Of course, many more work in such allied trades as equipment manufacture, feed, seed, veterinary medicine, engineering, financing, and distribution In fact, there are so many agriculturally affiliated industries that students have an almost unlimited choice of application for their basic agricultural training

Methods of managing dairy cattle have evolved slowly through hundreds of years of practice A great deal is known about keeping cattle healthy,

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duction and reproduction are curtailed Nevertheless, this curtailment is a form of life insurance, since all possible reserves may be necessary for flight or defense against attack, disease, or some other unfavorable manifestation Since just how the profit making functions are depressed during emergency mobilization of the animal s reserves will be discussed in detail later in this chapter it is sufficient for us to say here that conception rates are low production of milk virtually stops, and various secretory and digestive processes which it is our purpose to promote cannot normally occur in excited or uncomfortable animals In the case of dairy cattle, this effect is made all the more serious by the cow's associative faculties The mere sight of a person or place connected with an unpleasant experience can cause repetition of nature's life saving but profit cutting reactions

The Reproductive Impulse

Reproduction has many ramifications but the main purpose of this impulse (production of young) as well as its side effects (milk production, etc) are essential parts of sound husbandry *In fact, in dairy cattle management one might say that reproduction is the most important thing to promote* Milk is nature s food for the young and thus its production is a part of the reproductive process The physiological functions which promote normal reproduction are the ones which foster growth health and general profit-making animal functions In order to utilize the reproductive impulse it is essential to promote the proper coordination and physiological balance of the dairy animal

Coordination of the Body Systems

Dairy cattle are very complex organisms—perhaps more so than beef cattle or other comparable species because of the problem of physiological balance that exists among three complicated but closely related systems i e , the digestive, reproductive, and lactative systems Coordination of the many other systems in the organism is also necessary and requires an almost constant adjustment of the animal s body chemistry Improper coordination is the main source of physiological problems in animal production In the cow, the failure of the various systems to work together usually results in loss of productive ability Death itself often can be attributed to the failure of but a small part of the organism Thus healthy cells die because their vital needs are not served properly by an entirely different system from the one they function within

Single cell organisms have no such trouble They adjust directly to the varying physical and chemical environment It has been postulated and seems reasonable that many single cell organisms are immortal, they just divide and the parts live on

However, a complex animal has a tremendous number of systems, and all of them contribute to the life and productive processes Although nature coordinates the functions of various systems, managemental skills can help to foster this coordination just as such skills can improve the coordination of a machine An analogy can be made with the automobile The designers and engineers have planned the car so that its weight is distributed scientifically and so that the best sizes of wheels and tires can be selected and adjusted at the best angles Although this basic scientific coordination is essential, additional skills are also necessary, for the life of the tires can be prolonged by proper inflation and rotation Moreover, *preventive maintenance and careful usage are fundamental to long and* productive service of the entire machine The same principle applies to the husbandman as he seeks to utilize his skills in the conditioning of dairy cattle for long and productive lives

Conditioning

The cow's body distributes the work among its systems and does a great deal to maintain a steady internal environment despite changes in feed, temperature, atmospheric pressure, and the like Thus the composition of the tissues and fluids changes very little, even though the feed may vary considerably The body produces extra heat during cold weather and develops the ability to dissipate heat during warm weather Adaptations to drastic changes (such as extreme changes in weather, excessive work strain, or disease) occur as a result of adjustments of internal organs, the nervous system, and glandular secretions Such adaptations require time, but sup-*plementary managemental practices employing basic principles can smooth* out the transition period and prevent detriment to the systems which are of most economic interest One of the most important principles that the husbandman makes use of is the principle of conditioning

Conditioning is a term used frequently in modern psychology and refers to the utilization of an organism's attachment to a particular stimulus *in* order to produce within the same organism an attachment to an entirely different stimulus Thus a cow that has been eating a particular feed from a manger can be conditioned to eat a new feed by placing a small amount of it *in the same manger with the familiar feed and gradually increasing the* proportional amount of the new feed until the dairy animal readily accepts it Intelligent application of the principles of conditioning is very important to the successful management of dairy cattle In fact, work strain on the *various systems of the cow can be minimized by conditioning her* for each particular part of the productive and reproductive functions As a rule this is done by making changes gradually, so that undue strain is not placed on any particular system Feeding, grooming, housing, timing the

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lactation and dry periods, and breeding at proper intervals all play a part and are discussed thoroughly in later chapters *The principles of conditioning make up one of the manager's chief weapons in the successful utilization of the reproductive impulse and its side effects and in the minimization of the side effects of the survival impulse* For a fuller appreciation of the significance of the principles of conditioning we need to consider the concept of stress

STRESS

In recent years considerable interest has been expressed in the general term "stress" [1] Briefly, the *syndrome of stress may be defined as a definite pattern of change within the body when it is subjected to a disturbing influence (stressor)* These changes may be produced by fear, injury, infection, cold, heat, hunger, radiation, or other forces which cause the survival impulse to express itself, and can be dangerous to the organism because they have a detrimental effect in addition to the wear on the body and depletion of the cells caused by the normal life functions Moreover, because of the delicate interrelation of the reproductive and survival impulses, excessive stress can be exceedingly deleterious to the productivity of dairy cattle One can judge the success of managemental application of the principle of conditioning by the extent to which stress has been minimized

Modern-day stresses often are the result of long exposure to unusual or exhausting conditions The reaction to a stressor usually occurs in three major stages the *alarm reaction*, the *period of resistance*, and the *period of exhaustion*

may rise, (b) the blood pressure sometimes decreases considerably, (c) the blood is more concentrated because extra cells are discharged from storage, (d) permeability of the small blood vessels increases, (e) various chemical elements of the blood change as a result of emergency changes in the amounts of formed elements and glandular secretions, (f) the basal metabolic rate increases, and (g) the adrenal cortex reacts by producing an extra amount of the hormone desoxycorticosterone, which causes inflammation of tissues. It is thought that this is to localize injury. It does this, to be sure, but in addition the side effects influence functions of the entire body.

(2) During the second phase, *countershock*, the adrenal cortex, through the influence of ACTH,* secretes anti-inflammatory hormones which relieve to some degree the general effects of desoxycorticosterone. The points of injury are kept localized, however, by secretions which do not affect the organism so much as a whole. The local-adaptation syndrome (LAS) may thus protect a small part of the body. This can occur first and so prevent many, but not all, of the drastic side effects of the GAS.

To sum up: when only limited areas of the body are threatened, inflammation is useful in that it seals off the damage before it can spread. If wider areas are involved and it does spread, however, the body then produces anti-inflammatory hormones which, nevertheless, do not prevent irritations from occurring to some extent in all parts of the body.

Interference With Production Systems. Under adverse conditions, productive and reproductive functions are inhibited because they depend on extensive and well-coordinated work by systems of digestion and circulation, as well as by their own tissues. Inflamed organs generally do not function effectively and are likely to produce toxic substances. However, the anti-inflammatory hormones usually prevent serious threats to life from inflammation during the stage of countershock.

It is not surprising that during extreme stress young animals quit growing and lactating females cease production of milk. One of the first symptoms of the GAS is shrinkage of the sex glands. These reactions have been attributed to a shift in hormonal activity. Thus if the pituitary has to produce extra amounts of ACTH to make the adrenal cortex function at an increased rate, perhaps it must decrease production of hormones more closely associated with reproduction, growth, and lactation.

If the animal survives the alarm reaction, it adapts itself. No living organism could be maintained continuously in a state of alarm. If the

*ACTH is the general abbreviation for adrenocorticotrophic hormone which is produced by the pituitary gland. ACTH is one of the trophic hormones which regulate activities of other endocrine bodies.

alarm reaction results from conditions so drastic as to be incompatible with life, death is likely to result during the initial phase of the alarm reaction

Resistance

When survival is possible, the alarm reaction is followed by the stage of resistance—the second major stage of the stress reaction During this period the vital functions of the body approach normalcy It is an artificial adjustment, however, largely governed by the endocrine glands The pituitary gland secretes additional ACTH which causes in turn an increase in adrenal hormones As a result the body's supply of proteins, energy, and vitamins is utilized quickly and possibly to the point of depletion To make matters worse the ability of the body to replenish these substances is reduced Thus after prolonged exposure to the condition causing stress, the acquired adaptation is lost

Exhaustion

The third phase of the reaction to a stressor is known as the stage of exhaustion The symptoms of the initial alarm reaction occur again The final reserves of the body are mobilized and at times recovery may occur After a time, however, when the body reserves have been depleted, this phase becomes irreversible and death is certain

Reserves Within each living thing reserve strength is stored in various ways Some of the stores are available readily and others can be utilized only when absolutely essential to survival Often local fatigue is evident in the eyes in other sensory organs, and in muscles which have been used extensively During rest the body draws upon the readily available reserves, and thus even the stage of exhaustion is reversible in some phases

Adaptive Energy It appears that animals have only a certain predetermined amount of this special store of energy which Selye[1] called adaptive energy" This store may be determined genetically yet the possibility that it is influenced by feeding and management during early life cannot be overlooked Selye conducted a series of experiments to determine the facts It is evident that energy is required for an animal to adapt itself to an unnatural environment or activity and Selye's experiments, using laboratory animals at abnormally low environmental temperatures showed this to be true As a corollary, it seemed logical that once the body had become adapted to the cold environment nothing but deprivation of an ample food supply would prevent its continued resistance to cold This was not the case however Continued exposure to cold caused a continued drain on the body's store of adaptive energy

Additional work showed that the same principle applied to adaptation

to intense muscular exercise, and to tolerance to toxic substances and various other stressors One can but wonder about the tremendous metabolic effort of milk production in high-producing cattle

It appears that the *longevity* and *producing ability* of animals depends largely upon their individual stores of *adaptive energy Yet the only knowledge of this energy to date is that constant stress will deplete it* The only way to conserve it and still promote a productive life is to cooperate harmoniously with natural laws

Management of cattle thus could be compared to operation of a machine—an engine-driven forage harvester These machines store power in the flywheel Thus there is a reserve to help handle heavy forage The operator, however, can ease the machine over rough ground and slow its ground speed when wet or tough herbage is to be cut In this way, by careful management, he uses but does not deplete the power of the flywheel Careful management makes the fuel in the gas tank last longer too

We cannot use a machine or any other nonliving thing to contrive a valid analogy for the special store of adaptive energy which is available to an organism only as a last resort When stress in a local area uses up an organism's easily available energy, the organism becomes exhausted and is forced into inactivity while additional adaptive energy is mobilized from less readily adaptive stores However, when all the adaptation energy is depleted, exhaustion of the entire organism occurs

Starvation. The above processes involved in the depletion of adaptive energy can be observed during starvation Weight is lost readily to a point at which the wasting of body tissues seems to stop At this point, if feed is supplied, survival is possible If starvation continues until weight loss begins again, no amount of feed will prevent the animal's death Apparently during the interim, the body, in addition to other vital functions, uses its last store of adaptive energy

CONTROL OF BODY FUNCTIONS

Conservation of Energy

Energy conservation is important in dairying because the cow must transform so much of it by complex and perhaps seemingly inefficient processes Just circulating blood through the tiny capillaries of the udder—not to mention other parts of the body—requires a sensational amount of energy Over 7000 pounds of blood daily pass through the udder of an average 1300-pound cow Aside from other physiological, physical, and chemical energies, this mere job of circulation dissipates the equivalent of 100,000 foot-pounds of work daily

Homeostasis

During the nineteenth century the eminent French physiologist Claude Bernard taught that one outstanding feature of living things is their ability to maintain constant physical and chemical conditions within their bodies despite environmental changes Subsequently Walter B Cannon the famous Harvard physiologist called this ability *homeostasis* A good translation is staying power Thus the body tends to resist drastic changes

For example suppose one is losing weight The lighter he becomes the more difficult losing more weight becomes because less of the total nutrient intake is needed for maintenance On the other hand the larger one becomes the more difficult it is to add more weight because with each increment of added weight there is an increase in the amount of food needed to maintain the body

Homeostasis coordinates all systems of the body—enzymatic nervous circulatory excretory endocrine digestive and so on Thus changing atmospheric pressures do not cause reduction of the oxygen supply to the cells rather they trigger protective mechanisms In this manner extra blood cells may be released from storage hemoglobin concentrations may increase and the activity of oxidation catalysts is likely to be accelerated Fluctuating environmental temperatures do not cause changes in the body temperature of homeotherms This is because the homeostatic mechanism sets thermoregulatory forces into motion Decreased humidity does not cause dehydration because moisture conservation is emphasized as a result of the environmental effect on the body as a whole

Psychic Stimulation

Many responses which influence functions of the body can be set into motion by psychic stimulation These may become conditioned For example the first time a heifer comes into the milking barn she lets down her milk only after direct stimulation of the udder by massage and heat After several times however she responds to the familiar sounds and motions relative to the milking operations by complete letdown Experimental animals which have been put to sleep during experiments become drowsy upon being brought into the laboratory Appetite digestion absorption glandular secretions nervous activity and the like all can be controlled by mental association

The Conditioned Reflex As was previously suggested the conditioned reflex is one of the dairy manager s most useful tools if channeled properly It can however be the cause of such vices as biting kicking fence breaking and viciousness Such habits often can be broken by changing the stimulus since this inhibits the conditioned reflex Thus constantly gentle treatment is essential

The Autonomic Nervous System

Many functions of the body are controlled by the autonomic nervous system One part, the sympathetic, promotes speed, whereas another, the parasympathetic, tends to hold back vital functions to prevent overwork This applies to the eyes, the heart, the organs of digestion, secretions of glands, and conservation of nutrient stores in the body

These actions may be partially explained by another analogy to the automobile The sympathetic nervous system may be likened to the accelerator, the parasympathetic to the brakes One can drive a car with one foot on the accelerator and one on the brake, and lessening brake-pressure *or* increasing accelerator pressure will speed the vehicle Conversely, lessening accelerator pressure or increasing brake pressure will slow the car Thus balances and counter-balances forces and counter-forces are at work When one considers that thousands of systems are so coordinated within each living animal, the implications of homeostasis, LAS, GAS, and stress are seen to be enormous

Furthermore, since the body operates through many opposing forces, removal of some cause for abnormal reactions will not immediately normalize the body functions The situation is analogous to that of a swinging pendulum If the pendulum is released from one side, it will not immediately stop at dead center, but swings to the other side Thus returning to the analogy of the automobile, we find that if more speed is acquired by accelerator pressure and the accelerator is suddenly released with the brake still on, normal speed is not resumed, but the car's motion is abnormally slowed down By the same token, a cow without previous conditioning cannot use the correct amount of feed for maximum production by simply becoming "overfed " The same applies to unusual temperatures, humidity, and milking procedures—including numerous seemingly minor details such as the temperature of water used to wash the udder, the interval between milking, the position usually occupied in the barn, and the ingredients of the feed The dairy cow is known to be a creature of habit, and anyone who understands the nature of body functions can see why this must be

Types of Stress and Stressors

Anything which sets the LAS or GAS in motion may be considered as a stressor Not all stressors, necessarily, are objectionable Most forms of stress fall into one of four general types

(1) *Genetic stress*, which exists because cattle have been bred to produce at levels far higher than was possible in their wild ancestors The modern cow is not a natural animal

(2) *Nutritional stress*, the result of the tremendous feed requirements for modern milk production Here body functions in general are accelerated far beyond the activities required merely for normal maintenance and natural reproductive functions This principle applies not only to the digestive system, but to all organs Moreover, high production increases not only the maintenance requirements, but those for the production of normal rumen fermentation, and makes coordination of the numerous systems more critical Frequently, too, the ration is not composed of natural substances but of by-products from the manufacture of foodstuffs For example, such products as cottonseed hulls or ground corn cobs may be used in some areas to replace part of the forages in the rations Such materials are lacking in pigments and minerals which are in the natural feeds Moreover, unidentified nutrients may have been removed from the portion of the plant material used as animal feed

(3) *Managemental stress* Modern systems of mass production, including crowded feed lots, rushed milking dehorning, vaccination, veterinary examination, hoof trimming, and other managemental procedures generally adopted for man's convenience and profit, have added managemental stress comparable in its effects on the animal to emotional stress in human psychology

(4) *Disease*, even low level, nonspecific infection, results in stress

Although the importance of natural reactions should be obvious even from this short discussion, certain effects will be considered in more detail in other parts of the book Clearly, any animal which must react to a stressor has to compensate by a reduction in functions of production and reproduction Hence, a wise manager cannot fail to be impressed by the importance of careful handling, clean quarters with proper ventilation, a good supply of pure water, and adequate rations and feeding facilities, as well as control of disease, parasitism and even over-medication

2 SPECIAL FEATURES OF RUMINOLOGY

THAT CATTLE ARE RUMINANTS AFFECTS THEIR MANAGEMENT MORE than anything else, and, as will be explained, accounts for their use in market-milk production. Mare's milk is more nearly like human milk than the milk of cattle, and as much as 77 pounds of milk daily has been produced by Belgian mares observed by Blechschmidt[2]. Other mammals are also good milk producers. Why, then, is the cow used for this purpose? It is because, being a ruminant, she can change waste crops into food more cheaply and extensively than can any comparable animal. Thus the leaf and stem portions of many crops which, directly, are of limited use to man, poultry, or swine, can be profitably utilized as food for cattle. In this chapter the structure and function of the ruminant stomach as well as the related organs of the digestive system will be discussed, and the significance of ruminant metabolism will be indicated. There are four compartments in the ruminant stomach: the rumen, the reticulum, the omasum, and abomasum.

THE STOMACH COMPARTMENTS

The Rumen

Structure. From the standpoint of the entry of feed, the first compartment in the ruminant stomach is the *rumen*, and it is extremely large. Sisson[4] reported the capacity of the rumen of medium-size cows to be 30 to 40 gallons. This compartment is located largely on the left side of the body cavity. In the new-born calf it is inactive, and accounts for only five to seven per cent of the total stomach capacity. The rumen develops rapidly, however, and at maturity accounts for about 80 per cent of the total capacity of the ruminant's stomach.

The walls of the rumen are very muscular, and normally they contract rhythmically, giving a rotary motion to the contents. Pillars of muscular tissue divide the rumen into a dorsal, a ventral, and two posterior sacs. Papillae line much of the wall, making the absorptive area very great.

Function. The rumen serves as a storage place for such roughages as hay, silage, grass, corn shucks, and the like. Moreover, the rumen is the

fermentation compartment Thus in this compartment an opportunity is created for fibrous materials to soak and to be digested by microorganisms such as bacteria The coarser the feed the longer it stays in the rumen but all of it eventually passes on through the digestive tract Approximately 125 pounds of water and saliva enter the rumen daily

Microorganisms and Digestive Processes The rumen microorganisms are single cells thus they can act directly on their environment to get food As bacteria obtain their nutrient needs from part of the cow s feed many changes occur to make the remaining ingesta more fully utilizable by the animal

Bacteria are plants which develop with amazing speed their population doubling every 20 minutes under favorable conditions The bacteria themselves serve as cow feed just as do other plants There are also other kinds of valuable microorganisms in the rumen Some of the most important of these are protozoa (one celled animals) which are present in rumen fluids in tremendous numbers feeding on bacteria and changing plant nutrients to an animal form of very high quality Thus much of the protein eaten by the cow becomes animal protein in the form of protozoal cells—available to the cow s body through digestive processes In this way all the essential amino acids are provided The B complex vitamins Vitamin K and various other nutrients also are supplied as microbial by products

It should be noted that plant cell contents are exposed to the digestive juices produced in parts of the digestive system other than the rumen Thus energy may be released by bacterial action directly or later by enzymatic digestion however in either event the major work involved in the release of energy is dependent upon rumen functions

Gas Production Like other fermentive processes the fermentation occurring in the rumen results in the production of considerable gas Some of the gases are absorbed into the blood and eliminated by respiration and in a different form are passed in the urine A large part of such gases (methane carbon dioxide and others) are removed by belching

Occasionally animals are unable to remove such gases fast enough and they bloat i e they swell up with gas Since the topic of bloat is fully discussed in Chapter 12 we will simply point out here that this malfunction can be serious and sometimes cattle die from acute bloat Continuing research should solve this problem however

Comparison with Digestion in Other Species Other forage consuming species have compartments for soaking of feed and for bacterial action upon it The coecum of the horse acts in this capacity with the compartment for enzymatic digestion placed first and the fermentation compartment second However note that in the cow the fermentation compartment comes first *This makes products of the microorganisms actually available to the digestive and absorptive processes of the entire digestive system Hence a very large part*

of the feed of the cow can be roughage, and scientific cattle management must make use of this possibility

The Other Compartments

The Reticulum. The second stomach compartment, known as the *reticulum*, is only partially separated from the first compartment—it joins the ventral portion of the rumen These two compartments often are referred to as the rumino-reticular cavity The lining of the reticulum consists of honeycomb-like tissues It functions in the regurgitation process and participates in digestive functions as does the rumen The reticulum also catches hard objects and keeps them from reaching delicate parts of the digestive tract

Motility The cycle of rumino-reticular motility originates in the second compartment Rapid contractions characterize the initial part of the wave, a second movement following the first almost immediately These contractions force the liquid contents upward and toward the ventral sac The second movement is usually the more powerful, and so pushes the contents to the rear, resulting in a vigorous churning effect

The Omasum. The total function of the third compartment, the *omasum* (shown in Figure 2-1), is probably not clearly understood as yet It allows passage of liquids and possibly reduces the size of feed particles, though it does not seem likely that this could be the most important omasal function, since this organ accounts for only about 7 to 8 per cent of the total stomach capacity in mature cattle, and hence food could not remain there long enough for extensive processing

The location of the omasum is at the right side of the rumino-reticular fold (where the first two compartments join) It connects through a short free passageway Some of the laminae are studded with curved, horny papillae, as shown in Figure 2-1 The omasum removes much of the moisture from the ingesta, possibly by compression and absorption into the blood (Note the compressed feed between laminae in Figure 2-2) Although the omasum probably is a very important organ, its total function, as previously noted, is still somewhat of a mystery In addition to the other functions mentioned above, most likely some products of digestion are absorbed at this point

The Abomasum. The fourth compartment (Figure 2-3) is the true stomach, or *abomasum*, which functions similarly to the stomachs of other species Thus in the abomasum food is mixed with gastric juices, and food particles are reduced in size before entry into the small intestine Most chemical digestion and absorption occur in the small intestine of the ruminant as they do in other mammalian forms

The abomasum is lined with epithelial tissues which are folded many

fermentation compartment Thus in this compartment an opportunity is created for fibrous materials to soak and to be digested by microorganisms such as bacteria The coarser the feed the longer it stays in the rumen but all of it eventually passes on through the digestive tract Approximately 125 pounds of water and saliva enter the rumen daily

Microorganisms and Digestive Processes The rumen microorganisms are single cells, thus they can act directly on their environment to get food As bacteria obtain their nutrient needs from part of the cow's feed, many changes occur to make the remaining ingesta more fully utilizable by the animal

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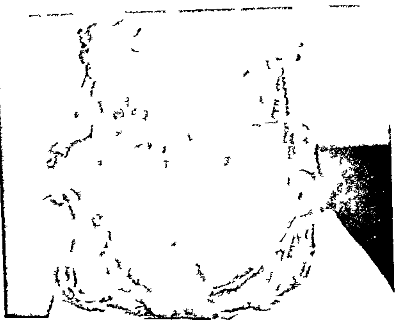


Figure 2 1 A longitudinal section of the omasum showing laminae extending downward from the top Note tough papillae at the top

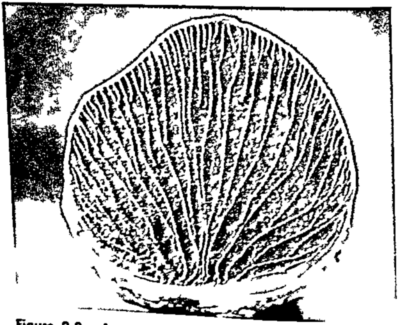


Figure 2 2 A cross section of the omasum Five different sizes of laminae extend from the outer curvature toward the med on short curvature (Courtesy Fla Agr Exp Sta)

Figure 2-3. Tissues of the abomasum; twelve spirals of mucus lining extend from the cardiac portion at the top to the constricted mid-portion. Tissues of the pyloric valve, which is the opening to the small intestine, can be seen at the bottom. (Courtesy Fla. Agr. Exp. Sta.)

times as shown in Figure 2-3, and hence affords a considerable gland-containing surface Various enzymes are secreted in different parts of the stomach Their action is controlled partially by that of the hydrochloric acid secreted by major cells near the pylorus (the opening to the small intestine). The acidity of the ingesta regulates the movement of partially digested food into the small intestine Hence the pyloric valve dilates when the stomach contents reach the proper degree of acidity, allowing the contents to pass.

While ruminant feed is usually rough and fibrous, containing hard sheaths and generally difficult-to-digest constituents, the mechanical and biological preparation of such feed by the first three compartments into which it enters, puts the efficiency of digestion in the true stomach of ruminants at least on a par with the gastric functions of single-stomach species

THE INTESTINES

Like the ruminant stomach, the intestines are a part of the digestive system in the dairy cow. From the intestines most of the nutrients are

absorbed into the body for metabolic functions aimed at conversion into energy, and the building of tissues, while at the same time waste products are prepared for excretion

The Small Intestine

The *small intestine* is a major organ of digestion and absorption in all mammalian species In the cow it is 120 to 150 feet long and holds 40 to 60 quarts The anterior section is lined with secretory cells and the posterior part contains many villi by means of which a considerable portion of the absorption occurs Enzymes of pancreatic juice, bile secretions, and those from intestinal glands attack every kind of food material which can be utilized by the animal

The Large Intestine

The *large intestine* is a continuation of the digestive tract, for collection of residues from other digestive organs It secretes no enzymes, though digestion does continue to some extent because of the enzymes carried in with feed residues Bacterial digestion occurs here also, as well as considerable water absorption

ASPECTS OF RUMINANT METABOLISM

Rumination

Normal cattle spend about one third of their time ruminating In this process food material is returned from the reticulum to the mouth—mainly by negative pressure This is accomplished as a result of a synchronized chain of events beginning with closure of the glottis by the epiglottis This is followed by a lifting action of the ribs, tightening of the diaphragm, and a general contraction of the ruminoreticular tissues The liquid is reswallowed immediately, and the solids are chewed thoroughly, reswallowed, and subjected to further digestion It is thought that the rumination reflex is stimulated by friction and pressure of coarse ingesta against the anterior wall of the reticulum

The Esophageal Groove

The esophagus leads from the throat through the chest cavity and enters the rumen high on the anterior wall Two folds of tissue lead from the opening of the esophagus to the opening between the reticulum and omasum These folds of tissue make up the esophageal groove (Figure 2-4), and when closed they take the form of a tube This closure of the esophageal groove causes liquid ingesta to bypass the first two compart-

Figure 2-4. The anterior portion of the rumino-reticular cavity. The esophagus is at the top and just below it the esophageal groove is shown in an open position. At the bottom of the esophageal groove, part of the reticulo-omasal orifice is visible. The papillated tissues at the top are typical of the rumen. The honeycomblike tissues at the bottom show the normal structure of the reticulum.

ments Solid feeds seldom, if ever, pass through the closed groove because their weight causes it to open, spilling the contents into the rumen or reticulum

The main function of the esophageal groove is to allow milk to go almost directly to the true stomach of the young calf This is particularly important during the first three weeks while the rumen is becoming functional In older animals, feed and water are swallowed directly into the rumino-reticular cavity This could make treating infections of the lower digestive tract a problem, since medicines given by mouth are likely to be diluted considerably before reaching the infection The problem can be handled quite

well however by chemical activation of the esophageal groove Ten milliliters of 10 per cent copper sulfate given by mouth usually is satisfactory for this purpose

Digestion of Nutrients

The basic nutrients such as carbohydrates fats, proteins, etc, are a part of dairy cattle s daily requirements as they are in human beings and other mammals However the digestion of these basic foods does not in every case originate in the same way in dairy cattle as it does in other mammals This you may have already anticipated because of the structure and physiology of the ruminant stomach

Carbohydrate Digestion No cellulose splitting enzymes are produced by the cow s body All cellulose used in ruminant digestion must be of dietary or rumen microbial origin Thus some of the plant enzymes taken in with the feed may help achieve the breakdown of cellulose in the rumen It appears, however that cellulose digestion in the rumen occurs mainly as a result of bacterial metabolism The bacteria gain entrance at any point where there is an opening in the plant structure Hence physical factors including shredding and grinding may influence materially the extent to which roughage is digested Extensive action of this type occurs only in the rumen

Lignin The lignin in plants does not appear to be digested even by rumen organisms Hence the lignin covering must be broken if bacteria are to reach and digest cellulose and other nutrients Thus soaking without the vigorous churning action of the rumen would be of little help After the lignin is ruptured the bacterial enzymes can digest the other feed components in the plants

Starch Starch granules also are digested by direct contact with the bacterial flora Generally the end product of starch digestion is glucose Starch can be fermented readily in the rumen It is utilized even more efficiently by hydrolysis in the small intestine Starch used in the rumen, however is an important factor in the health of the rumen bacteria

Fatty Acid Production Glucose formed by digestion of complex carbohydrates is further broken down to short chain fatty acids mainly acetic, propionic and butyric in the order of about 65, 20 and 15 per cent of the total[4] These acids appear to be necessary to normal rumen development (Figures 2 5 and 2-6) They appear to cause formation and maintenance of rumen papillae either directly or by an influence on the blood vascular system[2] Generally fatty acids may be of dietary origin or they may be formed in the rumen as a result of bacterial action on various feeds Apparently butyric acid also contributes to normal rumen functions[3] This

Figure 2-5. Rumens, normally papillated at top, and with reticular tissues at the bottom. These organs are from normally-fed steers which were 11-months old.

acid appears to originate partly from acetic acid and partly from proteins produced by microbial action

Protein Metabolism in the Rumen. Nonprotein nitrogen and carbohydrates from the feed are precursors of microbial proteins which become available to the host upon digestion in the true stomach and small intestine Anaerobic bacteria synthesize proteins from various nitrogenous

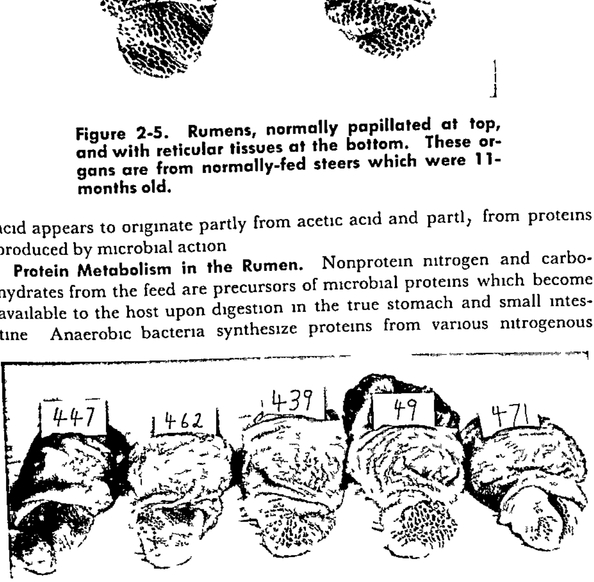


Figure 2-6. These rumens are almost completely devoid of normal papillae at the top. They are from 11-month-old steers which never received solid feeds. The limited papillation on No. 471 may have occurred as the result of fermentation of wood shavings which were used for bedding and consumed to a limited extent by all steers. Note normal reticulums at the bottom.

materials, including ammonia and urea The bacteria multiply very rapidly, reaching the maximum number in a period of ten hours or less following a meal

Role of Protozoa Rumen protozoa multiply less rapidly than bacteria, and reach their numerical peak after the bacterial growth is maximum The *protozoa* then feed partially on bacteria and partially on residues, and thus manufacture *animal proteins which contain all the essential amino acids* A large part of the dietary protein is thus broken down and resynthesized into these essential acids

Vitamin Synthesis The B-complex vitamins and Vitamin K in amounts adequate for the cow's requirement, appear to originate in the rumen due to microbial activity on carbohydrates, sulfur, and cobalt The cow synthesizes Vitamin C also, but this appears to occur in the body tissues rather than in the rumen

Features of Ruminant Digestion Dairy cattle are herbivorous animals They eat various forms of vegetation and live on a diet that would be according to human standards too high in carbohydrates However, because of the ruminant stomach, dairy cattle are able to eat large quantities of feed and convert it into nutrients so that their bodies obtain a sufficient amount of *proteins* and *energy producing nutrients* for tissue building and maintenance of body functions The tissues of the cow s body have about the same nutritional requirements as those of other warm blooded species The rumen functions, however, make it possible to supply feeds which are not usable by monogastric animals Rough feeds are broken down and poor quality nutrients are changed by bacteria and protozoa into excellent forms for use by the cow Moreover raw materials which, as such, are of no use to the animal, are converted into high quality proteins

Nevertheless, we should bear in mind that in subsequent discussions as we refer to a high protein feed we mean a high protein feed in terms of the dairy cattle's diet, and thus should not confuse this with what we ordinarily think of as a high protein diet for an omnivorous organism such as a human being It is also worth noting that rumination requires considerable energy In high-producing cows the processing of feed very likely places a considerable drain on the animal's store of adaptive energy

3 EVALUATION OF FEEDSTUFFS

WHAT IS A FEEDSTUFF? USUALLY, THE TERM IS EMPLOYED TO DENOTE AN ingredient used in a feed mixture The specific characteristics of various feedstuffs are discussed in Chapters 7, 8, 9, and 10 Various chemical entities needed by the body and found in feedstuffs, are known as *nutrients* A feedstuff must contain nutrients, though a nutrient per se is not necessarily a part of a feedstuff, since various vitamins, amino acids, etc , are available as pure chemicals

THE PROXIMATE ANALYSIS

Usually feedstuffs are evaluated by the so-called "proximate analysis " While the information obtained by this analysis may be of less value than the name of the process indicates, it serves the purpose of the herd manager By the proximate analysis the *dry matter* is separated from the moisture Though water is of extreme importance, *feed generally is evaluated on the basis of its content of dry matter* This is an especially important feature in the case of green forage, which may contain less than 10 per cent of dry matter and which frequently contains less than 20 per cent

In another step in the analysis, the *organic constituents* are separated from the mineral matter Although an animal could not live without minerals, all energy directly available to the body is in the form of organic matter Organic matter is separated further into those substances which are used *primarily* for energy, the *carbohydrates* and *fats*, and those which are used for repair and building of cell structures, the *proteins* * Since nitrogen rather consistently makes up about 16 per cent of protein, this constituent (as crude protein) is determined from the nitrogen assay Part of the remaining organic matter, ether extract, is especially high in energy, ether extract, being mainly fat, contains about 2 25 times the energy that can be obtained from other organic matter Separation of the carbohydrates is done by actual determination of fiber The remaining part is considered to be

*However, protein in excess of body requirements for repair and building of tissues can be converted to carbohydrates and used for energy

soluble carbohydrates including starches and sugars The soluble starches and sugars constitute the fraction of feedstuffs known as NFE (nitrogen free extract) The proximate analysis of feedstuffs is diagrammed in Figure 3 1

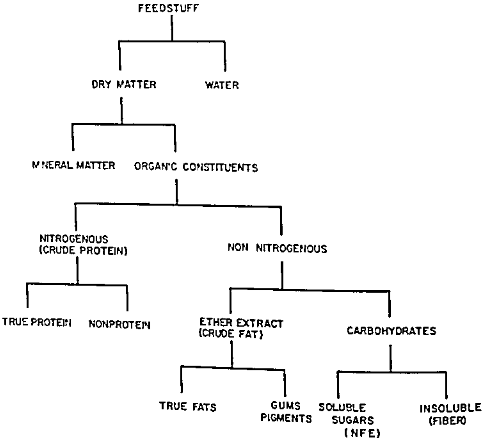


Figure 3 1 Proximate analysis of feedstuff

EVALUATION OF NUTRIENT UTILIZATION

Although proximate analysis would seem to yield considerable information about a feedstuff this method of separation could be misleading without some knowledge of the extent to which various nutrients from a given feedstuff are utilizable by the body The most widely used measure of nutrient utilization is *apparent digestibility* This is determined by subtracting the fecal output from the feed input Thus if during a test period an animal ate 200 pounds of protein and 60 pounds were collected in the feces 200 − 60 140 pounds apparently digested Apparent digestibility of protein in this case is 140/200 × 100 70 per cent

In a similar way the per cent digestibility (coefficient of digestibility) for NFE, fiber, and ether extract × 2 25 are added to determine the total digestible nutrients (TDN) TDN is a measure of the available energy of the feedstuff Available energy and protein are the main factors considered in ration calculations Although other feed constituents are just as important, usually they are present when energy and protein are supplied in sufficient amounts

The ratio of digestible protein to the nonprotein organic matter, including fat × 2 25, is known as the *nutritive ratio* When the ratio is wider than 1 6 appetite failure occurs in most species Thus some good cattle may be limited in opportunity to produce by lack of protein To make matters worse, if the nutritive ratio is too wide they may tend to fatten and give the impresssion that their ability is considerably less than it actually is

Calves also may get too fat on a very wide nutritive ratio Cutting the feed of these animals lengthens their raising time, whereas adjusting the nutritive ratio may make it possible for them to join the milking herd sooner

THE TREND TO MORE EXACT EVALUATIONS

Since the designation "apparent digestibility" implies an approximation, which it is, the TDN derived from apparent digestibility data is also an approximation This is important for the herd manager to know, because a misunderstanding of TDN and of the data derived therefrom often is at the bottom of mismanagement, though the results are not as detrimental, as a rule, as are various other factors of poor management Because of the need for more realistic and more easily applied values, the trend in animal investigations is now toward use of a more exact evaluation of feeds An explanation of additional terms will help to understand the present trends and how they apply to the management of cattle

True Digestible Energy

Metabolic residues, including worn-out cells, unused enzymes, bile salts, bacterial cells, and various other by-products of metabolism, usually appear in the feces Hence, there are some materials in the feces which were not in the feed If these metabolic materials can be determined and substracted from fecal contents to give the true feed residue, then feed *minus* true feed residues in feces *equals* true digestibility This is exactly the way in which true digestibility is defined in present texts on the subject Data based on this premise, however, are likely to be more misleading than TDN The reason is that gaseous wastes are not present in the feces They have been expelled, but their energy is still added to the so called "true digestible energy"

Metabolizable Nutrients

When gases and urinary residues are subtracted, a measure of metabolizable nutrients is obtained If determinations are on the basis of calories, the value is metabolizable energy This is a good indication of the value of feed and closer management of feeding will be possible when and if the metabolizable-nutrients content of a significant number of feedstuffs has been determined

The tendency has been to discount the importance of rumen gases, though they often contain as much as 4000 calories per day, which, as Brody[2] has pointed out, comprise about one-third of the maintenance requirements of a 1200 pound cow Do not infer that the large proportion of rumen gases indicates that feed is being wasted by the cow The rumen gases are derived largely from portions of the feed which could not be used by nonruminants This shows, nevertheless, that digestion trials which determine only feed input and fecal outgo tend to over-evaluate feedstuffs in terms of energy, expressed either as calories or as TDN It shows also that energy figures which are calculated from performance of cattle in terms of growth or milk production, are likely to over-evaluate forages in terms of energy Such calculations are further distorted by the effect of unidentified nutritional factors

Specific Dynamic Action

This discussion would be incomplete without mention of another nutrient loss known variously as the heat increment calorigenic effect of feed, thermal energy, thermogenic effect, or *specific dynamic action* (SDA)

Most texts at this time define SDA as the energy used in *digestion* of a given feed This is not true If the usual definition of SDA were true, this would be a rather simple determination and the true value of all feedstuffs could be made available to managers This would be a boon also to researchers, who could determine the true value of feeds from the performance of significant numbers of animals That SDA is *not the work of digestion* was proved by Benedict[1] in 1912 and corroborated by Weiss and Rappaport[7] in 1924 when it was shown that injected amino acids had the same SDA that occurred when they were included in the feed Although the occurrence of SDA was reported by Lavoisier and LaPlace[5] over a hundred years ago, an explanation of its significance in dairy cattle management has been ignored and the whole process side-stepped by the erroneous explanation that SDA is the work of digestion

Anyone managing cattle should understand the true nature of SDA because its effects can be used to advantage When they are not understood however, the effects can be ruinous Actually SDA is energy used in

the metabolic process *as a whole*, and this includes *the energy used in excretion of the end products* It is not constant for any given feed, animal, nor time Futhermore, SDA can be measured only as *heat* At times, therefore, it is as much a waste product as is urine or feces However, from the herd manager's point of view—and the cow's—heat is heat and is welcome during cold weather whether it comes from SDA or other sources

In our consideration of SDA it should be recalled that nature causes an increase in the tendency of animals to eat during cold weather This is good if extra feed is supplied, because at higher planes of nutrition, not only are more total nutrients available to serve as fuel, but a higher percentage of the consumed nutrients are converted into heat because *the SDA increases with the plane of nutrition* The important implication here is for the manager to understand that nutrient requirements are not standard, they vary with the process, weather, plane of nutrition, and type of feed

A classical example of investigation into the operation of SDA is the work of Rubner[6] which has been part of the literature for over 50 years Why hasn't more use been made of it? Rubner's work was done with a dog which produced 100 calories of heat per day when fasting One hundred calories of metabolizable energy were then fed in the form of lean meat, which is almost pure protein, and the heat production went up to 130 9 calories When 130 9 calories were fed 137 3 calories of heat were produced Finally, on the seventh trial at 140 1 calories of feed consumption, the heat production was about equal to the dietary intake It is important for the herd manager to remember that this occurs when protein is being used for the express purpose of supplying energy Remember too that SDA is heat, so when extra heat is needed, it can be obtained quickly from the SDA of additional protein On the other hand, when protein is used *as such* by the tissues, its SDA is almost negligible Therefore, when extra metabolic heat is detrimental, protein should be supplied only in amounts which can be used for normal production, reproduction, cell repair, and growth

Excess protein is deaminized, usually by one or more of the following means

(1) Simple deamination

$$\underset{\text{alanine}}{CH_3\ CH(NH_2)\ COOH} \longrightarrow \underset{\text{ammonia}}{NH_3} + \underset{\text{pyruvic aldehyde}}{CH_3\ CO\ CHO}$$

$$\longrightarrow \underset{\text{urea}}{CO(NH_2)_2} + \underset{\text{sugar}}{C_6H_{12}O_6}$$

$$+ \text{ 4 calories of heat per gram of nitrogen}$$

(2) Oxidative deamination

$$\text{alanine} + \tfrac{1}{2}O_2 \rightarrow \text{ammonia} + \underset{\text{pyruvic acid}}{CH_3 \cdot CO \quad COOH} \rightarrow \text{urea} + \text{sugar}$$
$$+ \text{ 4 calories of heat per gram of nitrogen}$$

(3) Hydrolytic deamination

$$\text{alanine} + H_2O \rightarrow \text{ammonia} + \underset{\text{lactic acid}}{CH_3 \cdot CHOH \quad COOH} \rightarrow \text{urea} + \text{sugar}$$
$$+ \text{ 4 calories of heat per gram of nitrogen}$$

The heat as indicated above accounts for about 20 per cent of the SDA In addition, there is considerable energy lost in excreting urea, as well as further enzymatic action on the other end products

In similar ways it has been found that SDA accounts for 15 per cent or more of fat and about 6 per cent of dietary carbohydrates Different researchers, using different reference bases, have found slightly different figures, but the principle is the same *Protein catabolism is responsible for most SDA which exerts itself as extra body heat* This can be useful or detrimental, depending upon conditions and management

Net Energy

If the SDA is subtracted from metabolizable energy the difference is *net energy* This measure of energy is close to the true quantitative value of any given feedstuff It is easy to see that net energy is difficult to determine directly, and indirect methods have not been used extensively Estimated net energy (ENE) has been calculated for a large number of feedstuffs All the basic data available are used for the estimate and this value appears to be coming into popular use

Feed Replacement Values

Another system of feed evaluation involves replacement values This system has been used in Scandinavian countries for many years Two groups of cows, comparable in size and milk production, are observed for a preliminary period during which they are fed a reference ration with barley In the second part of the trial, the barley is replaced in the ration of one group by an equal quantity of the experimental feed If the cows continue to produce at the same level and maintain body weight, the experimental feed is considered equivalent to the barley removed If not, quantitative adjustments are made until their effects are equalized The value of the experimental feed is then determined in terms of its replacement value of barley

Effect of Bulk. Of course complications occur due to bulk, which affects body fill. The worst feature of this system seems to be a lack of flexibility in the reference ration. If, for example, an oil meal is used to replace barley, complications due to fat and protein content would be certain. To overcome this difficulty, Kleiber[4] recommended a mixture of casein and glucose for the reference feed. Thus energy and protein in the reference ration could be varied to be commensurate with that of any experimental feed. Protein intake is considered even with present barley replacement trials, and the system is in general use in Denmark, Norway, and Sweden.

Other Methods

Depletion. The depletion method designed by Michigan workers[3] is particularly well suited for evaluating forages. This technique involves depleting lactating cows of their stores of milk-producing power by feeding only the forage under investigation. Part of the basal roughage then is replaced with an equal amount of TDN in the form of grain. Hence grain-equivalent values can be determined. The difficulty with this system is in the variability in individual reserves. Depletion times vary from one week to several months. Hence it is somewhat difficult to control depletion-type investigations, and the method has not been used extensively.

Starch Equivalents. Starch equivalent units still are employed in various parts of the world. They are used as a measure of energy in much the same way that TDN and ENE are. Actually the original data for starch equivalents were based on net energy values. They were converted to starch equivalents to make them most useful.

Feeding Standards. It seems obvious that nutrient requirements vary. Reasonable figures have been delineated through various studies, however. An extensive investigation recently was made by a committee on animal nutrition appointed by the National Research Council. The results are presented by special permission in Appendix D. Such tables, when used in conjunction with lists of feedstuff composition—one of which also is presented in Appendix D, are known as "feeding standards" and serve as practical guides for dairy managers. However, they must not be taken as empirical values. Feeding standards and nutrient requirements are discussed in more detail in Chapter 10.

Artificial Rumen Technique. Forage testing laboratories similar to present soil-testing facilities now are being established, and may be available universally in the near future. This is because laboratory methods are being developed to determine the nutritive value of feeds without the expense of animal feeding trials.

The method showing the most promise at present is the artificial rumen technique, in which the actual rumen liquor is removed through a fistula—

a permanent hole in the rumen which has been allowed to heal around a tube equipped with a cap (Figure 3 2) The digestive bacteria are supplied by removing some of the rumen contents through this tube to a container and small amounts of the test forage are added to the container along with

Figure 3 2 Researcher shown extracting a rumen sample through a fistula Note that entry is made on the left side of the steer (Courtesy Chas Pfizer & Co Inc)

a mineral solution The mineral solution maintains a normal rumen pH and essential inorganic nutrients for the bacteria Thus they are maintained in a partially artificial medium which approximates conditions in the rumen

The container then is sealed and incubated at body temperature for 24 hours From the digestion which occurs in such artificial rumens one can predict with reasonable accuracy the digestibility and conversion into energy of the test feed which would occur in actual use By this method also the digestible protein can be predicted from total protein with reasonable accuracy

Various experiments now in progress will help to refine these methods and to develop accurate determinations for voluntary consumption of the forage, also without feeding trials. This is needed because present methods do not give individualized information on the constituents determined by the proximate analysis. However, such methods can supply information to help the manager ascertain how to make the best use of the available forage. Thus, when one can have his forage tested for the amount his cows are likely to consume and for the amount that probably will be digested, it will be easy to calculate which supplementary feeds should be used. Since the nutrient requirements for maintenance and production are known (Appendix D), one can subtract the amount supplied by the forage from the total needed and determine what supplements are lacking and the quantities required to insure that the cows have the right amounts of proper nutrients at minimum cost. The actual mechanics of ration formulation as it is presently conducted is explained in Chapter 10.

4 PHYSIOLOGICAL EFFECTS OF HOT WEATHER

THE PREVIOUS CHAPTERS HAVE INDICATED THAT THE HEAT IN THE DAIRY cow s body is affected by the heat of the surroundings Let us elaborate The large amount of feed required for high milk production results in the production of considerable body heat Moreover fermentation in the rumen cellular metabolism and excretion of waste products all proceed at high rates thereby causing an increase in body temperature To make matters more serious the cow being a dry skinned animal has difficulty in dissipating body heat Thus hot weather is apt to limit production or tend to deplete the cow s store of adaptive energy In truth the cow is essentially a cold weather animal The manager should bear these facts in mind if he wishes to supply feed in the proper amounts during both winter and summer

The chief emphasis of the present chapter is upon the physiological effects of hot weather but the general questions of heat exchange and thermal equilibrium are treated in such a manner as to provide an adequate background for Chapter 5 where the effects of cold weather are considered

ANIMALS AND WEATHER

To place the present chapter in the proper perspective we will briefly examine the effect of an increase in environmental temperature on animals In the discussion that follows we will see that warm blooded animals (such as cattle) respond differently from cold blooded species (such as snakes lizards etc) to an *increase* in environmental temperature

The temperatures of the bodies of cold blooded species tends to be the same as the temperature of the surrounding environment Their bodies change in temperature with fluctuations in environmental temperatures in much the same way as do inanimate systems Thus the cold blooded species known as poikilotherms respond to a rise in environmental temperature as one would expect from the Van t Hoff law [6] which shows that (within limits) the speed of chemical reactions is doubled or tripled for an increase of 10°C of the system The principle has been demon

strated in that a 10°C rise in temperature caused the walking speed of ants to increase 2 1 times[15] and the metabolic rate of goldfish to increase 2 3 times[4] Alterations in body temperature thus caused reactions to vary just as they would have in nonliving systems

On the other hand, body temperatures of warm-blooded species, the homotherms, remain *almost constant*, as surrounding temperatures change Hence in these animals the *temperature* of the system does not vary directly with the environment Yet alterations do take place similar to reactions that occur according to the Van't Hoff law Thus although increasing temperatures of the environment do not necessarily cause a rise in body temperature or acceleration of metabolism as it does in the poikilotherms, it does stimulate counteracting mechanisms, such as increased respiration and perspiration rates In the homotherms the increase in respiration and perspiration rates approximate the Van't Hoff principle Although the body temperature of the cow remains almost constant, a 10°C rise in environmental temperature appeared to trigger mechanisms within the body which caused respiration rates to double[1]

THERMAL EQUILIBRIUM

Before considering thermal equilibrium in homothermic animals such as the dairy cow, we will examine this physical condition as it applies to the poikilotherms We have previously indicated that these cold blooded species change in body temperature as do their surroundings Consequently, they tend to reach a state of thermal equilibrium *Thermal equilibrium is that condition in which the heat given off by a system is the same as the heat absorbed by it* Such changes do involve energy since in cooling down to its surroundings the body gives up its heat energy When the temperature increases, energy is absorbed

The homotherms also tend to come into thermal equilibrium with their environment However, it must be remembered that their bodies must remain at an almost constant temperature The heat loss therefore must *equal* heat absorption *plus* heat production Thus when the environment is hot, dissipation of heat must be accelerated On the other hand, when the environment is cold extra heat must be produced and loss to the environment restricted Chemical and physical principles that one needs to understand and utilize in order to promote the tendency of homotherms to come into thermal equilibrium with their environment are as follows conduction, convection and radiation

Conduction

Conduction is a particle-contact process Hence, heat is passed from particle to particle of matter by an increase of activity If, for example, a

piece of metal is heated at one end the molecules and electrons at the point of heating are given extra kinetic energy by vibratory motion The heated particles share their increased activity by contact with neighboring particles which in turn pass part of their increased kinetic energy to those beyond Thus the energy of agitation is transferred across the metal as heat The particles of some substances are set in motion more easily than are those of other materials, and hence are better conductors of heat

Metals, for example, are good conductors and woods are not If one touches a piece of hot iron and a piece of wood at the same temperature, the iron feels hotter because it conducts heat to the hand at a higher rate If the objects are cold, the iron will feel colder because it conducts heat from the hand at a more rapid rate Air is a poor conductor compared to water This is one reason why cattle find some relief from the heat by standing in a pond or stream

An animal loses heat by conduction through its skin and through excreted material Heat conduction is due to a property of a material that allows heat to pass through it Even though a body is impermeable to air, it may still have the ability to conduct heat The amount of heat exchanged by conduction is governed by the following equation

$$Q = UA(T_1 - T_2)$$

In this relation, Q is the quantity of heat which is transferred within a given time, and A is the area of a cross section of the body through which the heat moves Naturally more heat can pass through a large body than through a small one, just as more water can pass through a large than through a small hose

The heat transfer coefficient U is high in the case of metal or water, which are good conductors and low for wood Thus an animal body, being composed largely of fluids transfers heat readily It has a fairly large coefficient of heat transfer when compared to hair which impounds considerable air and hence is a poor conductor

$(T_1 - T_2)$ refers to the temperature difference that exists between the body and its environment If this difference is great (as it is likely to be during the winter), cooling may be very rapid, whereas if there is a small gradient, heat transfer through even excellent conductors will be slow

Heat that is transferred from the skin by other means must be conducted through the skin tissues and fluids of the animal In this respect heat conduction plays an important role in cooling animals Actual heat conduction from the animal's skin surface to the air is very small when compared to other modes of heat transfer It may be important however, particularly during the summer when the hair is short and sleek

Convection

The nature of convection may be described easily by reference to a vessel of heating water (Figure 4-1). Currents are set up when the water immediately over the flame becomes hot This is because heated water expands and becomes less dense The colder water then pushes the heated portion up and, taking its place, becomes heated in turn Thus as it rises, currents are established

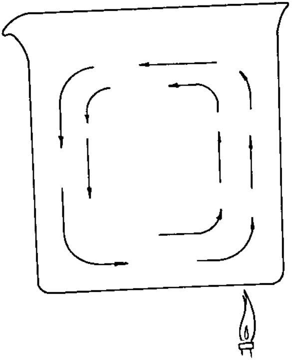


Figure 4-1. Convection currents in a beaker of heated water.

In the same way, air can circulate around any heating body, such as that of the cow If the heated air is removed quickly by fans, there is more tendency for other heated air to rise, and in this way moving air cools even dry-skinned animals by aiding the convection process Thus heat is picked up by moving air from an animal's body and is transported elsewhere The amount of heat exchanged in this manner is governed by the relation

$$Q = CAV^n (T_1 - T_2)$$

where Q is the heat transferred per hour, A is the surface area of the animal, V is the air velocity, and $(T_1 - T_2)$ is the temperature difference between the animal's skin and the air circulating around the animal The coefficient, n, in the velocity term, V, simply indicates that the amount of heat transferred does not change directly with a change in air velocity The convection coefficient, C, depends on the characteristics of the skin surface of

the animal In the case of cattle such things as length of hair its thickness and whether it is curly or straight influence the value of C Hence animals with short sleek hair give up body heat to the environment more quickly than do those with more of an insulating cover More heat is transferred from a large than from a small body Speeding up the air flow will increase the speed of heat transfer but not in direct proportion Naturally the colder the air the more quickly cooling occurs

Air Movement Air movement over the skin of an animal can increase the rate of convective heat lost from the animal Kibler *et al* [8] have reported benefit from fans At 95°F and with lactating Holstein cows a 10 mph air movement from fans lowered rectal temperatures by about 2°F from those observed with an 0.5 mph air movement Brody *et al* [2] reported very little increase in milk production due to the effects of wind at environmental temperatures of 80°F However definite benefits were noted at 85°F It was observed that 5 and 10 mph winds recovered 10 per cent of normal milk production that otherwise was lost during exposure to 85°F temperature and 65 per cent relative humidity (air velocity equal to 0.5 mph) The 5 and 10 mph winds were even more beneficial at 90°F

Radiation

Radiation is the transfer of heat by electromagnetic waves across space A hot body is able to radiate because its electrons and atoms vibrate more rapidly and hence produce waves which travel away from the body When these waves strike a body which is cooler than the one from which they originated they induce vibrations in the atomic structures of the cooler receiving body and this results in heat Thus heat travels from a warmer body to a cooler one Heat will go from a warm animal to a cold wall or from a hot wall to a cooler body

Emissivity and Receptivity The tendency of a body to be affected by radiation is proportional to its emissivity and receptivity which are determined largely by the quality of the surface All surfaces tend to absorb or emit electromagnetic waves dull surfaces being high in emissivity polished surfaces low Emissivity of the skin is 97 per cent Hence if the environment is hotter than the body the skin absorbs 97 per cent and reflects only 3 per cent of the radiant heat

The relation governing the rate of radiant heat transfer is given by

$$Q = ADEF(T_1^4 - T_2^4)$$

where again Q is the rate of heat exchange A is the area of the surface and D is a constant The value of E is the emissivity Emissivity depends on how well the surface under consideration emits and absorbs radiation and often is a controllable factor in cattle comfort The term F involves

the shapes of the objects between which radiant energy is being transferred, and T_1 and T_2 are the temperatures of the bodies between which heat transfer occurs

The sky is an important source of radiation because of its size To the north, however, the sky generally is cooler than the animal-surface temperature, and can be used to advantage to absorb radiant energy from the animal

Effect of Surroundings Corral fences influence the radiant heat lost or gained by enclosed animals, and the ground surrounding an animal is also an important source of radiation Measurements made by Ittner, *et al*[6] show that radiant energy from the lower hemisphere (immediate ground and surrounding crops) may be as much as 40 to 60 per cent as great as that from the upper hemisphere (sky) This radiation is due to the temperature of the ground surface plus the reflected energy from the sky The characteristics of the ground surface have an important effect

Studies at the Florida Agricultural Experiment Station show that during the day air temperature a few inches from the ground often is 20°F warmer than at 5 feet, but at night close-growing plants often are 10°F cooler than the temperature 5 feet above them

One set of measurements in the Imperial Valley in California at 1 00 P M showed a total radiation intensity from the sky (upper hemisphere) of 447 BTU per hour per square foot (This amount of energy falling on 100 square feet would be enough to run a 15-hp electric motor) With this sky condition existing, it was found that the total radiant energy from bare ground (lower hemisphere) amounted to 277 BTU per hour per square foot, and from a field of alfalfa 198 BTU per hour per square foot The alfalfa covering decreased the ground radiation by 28 5 per cent In the same location with air temperatures of 89°F the following ground temperatures were observed

Hard ground, trampled by cattle	124°F
Hard ground in road	129°F
Soft ground not trampled by cattle	132°F
Dry rotted manure in feed lot	148°F

These figures indicate the relative ability of different ground materials to conduct and radiate heat Brody, *et al*,[3] have determined that the effect of radiation intensity on milk production can be drastic

ACHIEVING PRODUCTIVITY

The zone of thermal neutrality for milking cows was found to be between 30° and 60°F, depending on breed and level of production *Thermal neutrality* is the range of environmental temperatures at which heat pro-

duction is equivalent to heat removed by physical processes Chemical regulation is unnecessary and the animal feels neither too hot nor too cold It is analogous to the comfort zone for man (72° to 85°F) which is used in air conditioning engineering However other physiological factors are involved in achieving satisfactory milking results and these factors make it unnecessary to maintain such low temperatures

Ragsdale *et al* [3] reported a drop in production beginning at about 80 F for Holsteins and 85°F for Jerseys McKenzie and Berliner [0] have shown also that reproductive functions of rams decline at about the same temperatures

The effects of heat are tempered by humidity because the conduction capacity of the air is increased and because the loss of moisture from the skin is depressed as humidity increases At a relative humidity of 44 per cent or below temperatures up to 85°F are likely to cause only slight declines in productive processes High relative humidity however causes distress during hot weather and makes relief more difficult Moreover during cold weather high humidity makes it harder for dairy cattle to keep warm because the increased conductivity of the air causes heat to be removed from the body more rapidly

Aid of Physiological Factors

In warm weather the body is maintained at an almost constant temperature and productive processes are upheld by the following physiological factors

(1) The blood is diluted somewhat during the summer thus increasing the total volume and making it easier for body heat to be carried to the surface

(2) Pulse rates in all *sweating* species increase in order to pump blood to the surface faster In dry skinned species when more heat is absorbed from the surface than is dissipated there under extreme conditions the pulse rate slows to keep blood *from* the surface When this occurs in lactating cows production is likely to drop sharply

(3) Body fat is part liquid and part solid A larger part of it is liquid during the winter whereas most of it solidifies in the summer There is not as much need for quick mobilization and metabolism of fat during warm weather and hence the energy necessary for these processes can be saved for other purposes

(4) The liver is lighter during warm weather Less metabolism is necessary

(5) The adrenal and thyroid hormones change in relation to each other and to choline thus stabilizing warm weather metabolic rates and nervous activity

(6) Since blood volume and circulation routes vary, the extent of the peripheral vascular bed varies to take care of the changing conditions

Adjustments to Stress

These adjustments occur normally when the change from cold to hot environmental temperatures is gradual, however, *when cows in climatic chambers were subjected to sudden increases in temperature, production usually dropped very rapidly* Gradual changes have resulted in slower and less severe reduction in milk output In fact, dairy cattle at the Georgia Coastal Plain Experiment Station were able to maintain high production during hot weather when no shade was provided[7] These animals had access to shade on a free choice basis for several months, however, before assignment to experimental groups

Additional research on preconditioning for hot weather is needed, yet it seems logical that if relief can be obtained periodically that conditioning can occur gradually with no drastic detrimental effects How much drain the maintenance of summer conditions puts on the store of adaptive energy needs further investigation Although adapted cows on the experiment in Georgia[7] maintained high production, they appeared to be uncomfortable and exhibited abnormally high rectal temperatures No doubt there was an increased drain of adaptive energy

Advantages of Evaporation. One important factor that aids the cow to adjust to heat stress is evaporation Heat energy is needed in the transition from liquid water to vapor and must come from some source by one or a combination of the modes of heat transfer The rate at which heat is removed is expressed as

$$Q = KAV^n\lambda(P_s - P)$$

where again Q is the quantity of heat lost per unit of time, V is the velocity of the air, A is the area (this time of the surface, because that is where evaporation occurs), and λ is the latent heat of vaporization—i e , the amount of heat required to vaporize a given amount of liquid In the case of water this is 1050 BTU per pound ($P_s - P$) depends upon relative partial pressures of water vapor at the animal's surface and in the surrounding air (thus humidity plays an important role) The evaporative constant, K, like the convective coefficient, is affected by the type of surface and its directional relationship to the flow of air In this relation, n is entirely similar to that in the convective relation shown on p 33 The heat used in the evaporative process, λ, comes from the animal's body and from the environment

It is not unusual for a human being to lose as much as three quarts of liquid per hour by perspiration Above 100°F almost all heat dissipation in freely sweating species is by vaporization

At 104°F the human body absorbs as much heat from the environment as it produces Hence thermolysis is 200 per cent of thermogenesis Normal output at such high temperatures is possible only because of vaporization Kuno[9] pointed out that the critical temperature for sweating in man was about 29°C (or 84°F) Later Erickson *et al* [5] reported it to be closer to 26°C

However cattle are not profusely sweating animals since they have few functional sweat glands Most of the vaporization therefore is from the respiratory passages Brody[2] pointed out that this puts cattle at a distinct disadvantage since profusely sweating species dissipate two thirds of their heat controlling moisture from the surface of the skin This is not to say that no moisture is lost through the skin of cattle Mitchell and Hamilton[10] noted that steers lost 15 per cent of their heat by vaporization at 43°F More than 42 per cent was lost in this way at 79°F

Moisture loss does not increase much above that temperature however Brody pointed out that at an environment of 80°F the temperature of the cow already was above normal This is about the point at which production usually begins to decline Reduced production generally has been accompanied by lowered feed consumption Lack of feed is not at the root of the problem however since production often decreases before appetite is affected Nevertheless forage quality is likely to decline during hot weather and unless this is taken into consideration undernutrition still may be involved

Countermeasures for Heat Stress Although the magnitude of the difference between body and environmental temperatures determines by physical means the rate of heat *loss* the rate of heat *production* in dairy cattle must be determined in part at least by the *level* of production Hence the degree of environmental control which is feasible cannot be defined easily although fundamental animal information can help Nevertheless above the critical temperature productive processes must decline unless physical and/or chemical countermeasures are employed Below the critical temperature the body temperature is regulated largely by chemical reactions

Cooling Cattle One of the most important countermeasures to heat stress is *cooling* with moisture Seath and Miller[14] found sprinkling to be very effective in reducing the body temperature of cattle This was true especially when a gentle breeze also was provided

Loose housing type sheds or other structures with sloping concrete floors sprinklers and fans large enough to insure movement of air possibly could go a long way toward solving the problem of summer slump in milk production at least by making the transition from cold to hot weather conditioning gradual thus conserving adaptive energy

Since sprinkling especially if accompanied by the use of fans reduces

body temperatures drastically, care must be taken to prevent chilling Considerable pneumonia has occurred from cooling over-heated cattle too quickly

Air conditioning and Related Techniques Air-conditioning for cattle, though not yet technically feasible, often might be effective by reducing environmental temperatures only slightly Moreover, it may be sufficient to cool the manger only to supply cold, dry air for breathing Any air-conditioning system designed for dairy cattle, however, must embody important differences from conventional systems Present air-conditioners recirculate much of the air in the cooled space In dairy structures, dust and ammonia in the atmosphere would require the use of large, special filters and possibly of noncorrosive cooling and duct surfaces If only the manger area is cooled, moisture from respiration still will create a special problem It might even be necessary to avoid recirculation and to use 100 per cent conditioned fresh air

From the foregoing it seems obvious that air conditioning or a system of sprinklers and fans could allay much of the hot-weather slump in milk production The extent to which these processes can be used profitably has not been determined

If relative humidity is low, the temperature inside a building can be reduced directly by evaporation of water Evaporative coolers consist of a metal cabinet filled with a fine absorptive substance which has been wet thoroughly Air is pulled from the outside through the moisture laden lining and into the room Thus direct evaporation of moisture offers a fine system for cooling buildings including cattle barns in dry climates It is not practical in damp localities, however

Other applications of basic principles which seem sure to help include (a) shade shelters, (b) a convenient supply of shaded water, (c) calving to cause peak production during cool weather, (d) proper feeding, and (e) use of greenchop and night grazing

Shade Shelters Shade shelters generally are rectangular, and hence provide shade for more hours of the day if they are placed in an east-west position On the other hand placing them so that the length faces the trajectory of the sun reduces their effectiveness However, this placement provides a considerable amount of natural disinfection, since the entire sheltered area is likely to be irradiated daily Plastic shades stretched over inexpensive wire supports are effective, though their emissivity is considerably higher than is that of bright metals

Galvanized iron or aluminum costs more than plastic, but these metals can be made into permanent shelters They are low in emissivity and hence do not absorb as much radiant energy as do most other materials The emissivity of the side next to the cows can be increased by coating it

with asphalt or with other materials which absorb radiant heat easily. Thus these shelters can be made to resist radiant heat from the outside while absorbing heat from the cows and the ground.

Painting the upper side with chalking white paint results in lower roof temperatures. The correct height to allow for effective convection currents is about 12 feet, and this height is suggested for use in the northern part of the United States. In the southern sections, where the sun's rays slant at a greater angle, the roofs should be only high enough for most machinery to operate under—unless air circulation is considered especially important. In this case some compromise will be necessary. An area of at least 60 square feet per cow is desirable to prevent crowding. Shelters of this type appear to reduce the radiation heat load on cattle about 50 per cent.

In the South, self feeding hay barns with covered feeding areas have been used to relieve some heat stress. The only objection is that such structures cannot be open on all sides and hence removal of heat by convection is ineffective as compared to shelters, even very low ones, having cross ventilation.

The Water Requirement. Another consideration is the availability of an adequate supply of water. During the hottest months, the main leafy roughage usually is one of the permanent pasture grasses. These are relatively low in moisture content, supplying an average cow approximately six gallons of water daily compared to as much as 15 to 20 gallons from succulent cool weather forages. This is complicated further by the fact that hot weather causes an increase in the animal's requirements for water, as shown in Table 4.1. Yet they will walk no more than a few feet for it.

Table 4-1. Gallons of Water Required by Cattle—Providing 50 Pounds of FCM Daily[3]

Body Wt (lbs)	Temperature (°F)					
	40	50	60	70	80	90
800	17.2	18.0	20.3	22.8	25.3	31.6
1000	17.8	18.8	21.1	23.8	25.4	33.2
1200	18.5	19.5	22.0	24.7	27.5	37.1
1400	19.5	20.6	23.2	26.2	29.2	37.1
1600	20.2	21.3	24.0	27.2	30.3	38.7

Therefore many more watering stations are necessary during hot weather than during cool if production is to be maintained. Shade over the troughs can prevent most heating of the water by solar radiation.

Properties of feed other than their content of moisture also affect the ability of cattle to withstand warm weather.

Level of Feeding Overfeeding, particularly of proteins, is objectionable because of the accompanying increase in the heat incidental to the total function of feed utilization As previously explained (page 24), the term for this extra heat increment is "specific dynamic action" You will recall that SDA is measured as heat, and it varies with the type and amount of feed as well as with the process for which it is to be used Since SDA produces heat, it may be helpful during cold weather, but generally becomes a waste product during hot weather

Effect of Fiber Fiber intake likewise is important, since fermentation of this feed component usually is accompanied by excessive rumen heat Work by Peters, *et al*,[11] at the Texas Agricultural Experiment Station, College Station, showed that cows were cooler on low-fiber than on high-fiber rations This determination was made on the basis of respective pulse rates, respiration rates, and rectal temperatures

Other Considerations High production causes an increase in metabolic heat, and if the weather prevents removal of waste heat, complications resulting at least in a reduced level of production are inevitable When possible, the calving season should be confined to the fall months so that peak production will occur during the winter Usually new grasses in the spring will cause a second stimulation which keeps production up until hot weather, when from the cow's point of view, low production (or the dry period) is ideal Of course the base period and demand for milk temper the application of this principle Since the amount of milk delivered to the plant during the base period determines largely the price paid for milk during the entire year, the highest feasible production is in order, even if this occurs during hot weather

Producing cows do three-fourths of their grazing at night if given a chance Hence, green chopped feed supplied in a shady place close to water will keep roughage consumption high during the day, and at night pasture can furnish the remaining roughage Only high quality forage can be expected to produce the desired results Since the quality of permanent grasses usually declines during the summer, the annuals are recommended for both pasture and greenchop during hot weather Unless forage quality is maintained, extra portions of palatable concentrates will be necessary

5 PHYSIOLOGICAL EFFECTS OF COLD WEATHER

ALTHOUGH THE COW IS BY NATURE A GOOD COLD-WEATHER ANIMAL, reduced milk output may be expected during *sudden* cold snaps. Field reports show that such losses amount to as much as 26 per cent of the cow's daily production. An understanding of why sudden cold weather is detrimental to milk production, whereas normal winter weather is beneficial, will enable the herd manager to work with nature during this season to keep production at a normal level.

PHYSIOLOGICAL ADJUSTMENTS

In Chapter 4 we described how the cow's body was aided in its adjustment to the stress of hot weather by certain physiological changes. Now we see that most of the factors outlined in the previous chapter (page 36) apply *in reverse* to cattle under conditions of possible cold stress. Thus as the weather becomes colder, the following physiological adjustments can be expected.

(1) Blood volume decreases, thus conveying less heat to the surface for dissipation.

(2) Insulating properties of the skin are likely to be enhanced. This is accomplished by

   (a) an increase in subcutaneous fat,

   (b) a decrease in the vascular bed,

   (c) a growth of thicker, longer hair which, by its dry nature, tends to retain more dead air next to the skin,

   (d) hormonal and other biochemical changes, which help condition the nervous system to keep the hair in patterns which hold considerable dead air and thus give it the best insulating properties. Shivering and increases in muscular tension also occur as a result of winter changes in body chemistry.

(3) It seems likely that the SDA of feed is increased, though it has been postulated by Blaxter[1] that in sheep there is no SDA below the critical temperature. You will recall that below the critical temperature the body temperature is regulated largely by chemical reactions. Probably the actual biochemical functions incident to feed utilization vary

little with environmental temperatures. Rather it is the body's reactions which fluctuate depending on whether the metabolic heat can be used to maintain body temperature or whether it must be dissipated at the expense of energy. Rubener[5] found that 320 grams of meat consumed by a dog at 7°C caused no increase in heat production, whereas the same diet at 30°C resulted in a 50 per cent increase. It was theorized that at 7°C basal metabolism was higher and the extra heat of SDA replaced some of the heat of chemical regulation.

(4) During cold weather more of the body's fat is kept in liquid form for ready metabolism.

(5) Appetite increases at low environmental temperatures.

As weather gradually becomes colder, thyroxine production is stepped up. This hormone stimulates general metabolism. It causes more feed to be consumed, and speeds up the rate at which feed is used (and heat produced) in the body. Thus when other conditions are favorable, milk production is likely to increase and the cow is warmed by metabolic heat.

As mentioned previously, cattle are a minimum-sweating species. However, they do have sweat glands, the effect of which is small. These sweat glands are apocrine and have a poor blood supply. The secretion of cattle sweat glands is largely mucopolysaccharide.[3] Chlorides do not appear to be secreted, and little moisture reaches the surface via these glands. In fact, the skin usually is dry. Thus wind alone does not have a drastic effect on heat dissipation. Although some heat is removed by convection, this is seldom harmful.

EXTREME COLD

For all animals there is a zone of thermal neutrality. Within the range of the temperatures in this zone, the environment is such that the body temperature remains normal without chemical regulation and the animal feels neither too hot nor too cold.

Below the critical temperature physiological adjustments cause more heat to be generated and conserved in the body. However, it is possible for the environmental temperature to become so low that the body-regulating mechanisms no longer can cope with the cold. Then the body temperature becomes subnormal and production decreases sharply. Just what this temperature is depends upon several factors:

(1) *Maturity*: immature animals have a smaller thermogenic reserve than mature ones. Hence they need more protection.

(2) *The sweating mechanism*: dry-skinned animals stand cold weather better than profusely sweating species.

(3) *Relative humidity*: when humidity is high the hair and skin covering conduct heat from the body more readily than when the air is dry.

(4) *The skin covering* heavy, dry hair arranged to enclose the maximum dead-air space increases the thermogenic reserve over that occurring with sleek haircoats
(5) *Ratio of surface to weight* large animals have less surface in relation to weight than do small ones and thus can conserve heat somewhat better This is tempered to some extent by the fact that basal metabolism also is a function of surface, and hence large animals produce less heat in relation to body weight than do small ones
(6) *The original body temperature* in the case of the cow, normal temperature is quite high—about 102°F Hence the tolerance to cold is some what greater than in many other species

MANAGEMENT MEASURES

Function of Shelter

Moist-skinned species can become chilled easily in a cold wind Cows are subject to this source of chilling too if they are unsheltered during cold, blowing rain The main purpose of winter cattle shelters is to keep cows dry The next most important function, wind protection, can be provided by a large open shed Usually, three sides are walled, and one side remains open The adequacy of open sheds has been proved by research at various experiment stations In general, cows housed in open sheds had keener appetites and consumed more roughage than those kept in closed barns As long ago as 1907, Waters[6] noticed that cattle wintered outdoors in Missouri did better than those in conventional barns Dice[2] has shown also that dairy cattle wintered outdoors (at 9° to 27°F) produced as well as comparable animals kept indoors This should be expected, since Jordan[4] demonstrated that dairy cows generated 55 to 85 per cent more heat than they needed to maintain normal body temperatures

In some, but not all, loose-housing systems for cattle, more bedding is required than in closed barns, however, cows are easier to keep clean in open sheds than in closed barns When open sheds are used, it is advisable to partition off a small area at one end for confining cows which are to be segregated for veterinary attention or breeding

Cattle wintered in the open need plenty of room because there is more tendency to exercise From this standpoint (and biologically speaking) closed barns with heat regulation may be better However, the economics of heating cattle barns is still questionable, and since bovine physiology is particularly well adapted for cold environments, the open shed seems to be the best answer at this time

Emergency Measures

Acclimatization is very important in the adaptation of cattle to cold weather If the weather changes gradually, the body chemistry will adjust

(4) *The skin covering* heavy dry hair arranged to enclose the maximum dead air space increases the thermogenic reserve over that occurring with sleek haircoats

(5) *Ratio of surface to weight* large animals have less surface in relation to weight than do small ones and thus can conserve heat somewhat better This is tempered to some extent by the fact that basal metabolism also is a function of surface and hence large animals produce less heat in relation to body weight than do small ones

(6) *The original body temperature* in the case of the cow normal temperature is quite high—about 102°F Hence the tolerance to cold is somewhat greater than in many other species

MANAGEMENT MEASURES

Function of Shelter

Moist skinned species can become chilled easily in a cold wind Cows are subject to this source of chilling too if they are unsheltered during cold blowing rain The main purpose of winter cattle shelters is to keep cows dry The next most important function wind protection can be provided by a large open shed Usually three sides are walled and one side remains open The adequacy of open sheds has been proved by research at various experiment stations In general cows housed in open sheds had keener appetites and consumed more roughage than those kept in closed barns As long ago as 1907 Waters[6] noticed that cattle wintered outdoors in Missouri did better than those in conventional barns Dice[2] has shown also that dairy cattle wintered outdoors (at 9° to 27°F) produced as well as comparable animals kept indoors This should be expected since Jordan[4] demonstrated that dairy cows generated 55 to 85 per cent more heat than they needed to maintain normal body temperatures

In some but not all loose housing systems for cattle more bedding is required than in closed barns however cows are easier to keep clean in open sheds than in closed barns When open sheds are used it is advisable to partition off a small area at one end for confining cows which are to be segregated for veterinary attention or breeding

Cattle wintered in the open need plenty of room because there is more tendency to exercise From this standpoint (and biologically speaking) closed barns with heat regulation may be better However the economics of heating cattle barns is still questionable and since bovine physiology is particularly well adapted for cold environments the open shed seems to be the best answer at this time

Emergency Measures

Acclimatization is very important in the adaptation of cattle to cold weather If the weather changes gradually the body chemistry will adjust

to the changing environment If the change is sudden, however, emergency physiological measures must be taken There are various reasons for this Thermogenic (heat-producing) processes are stepped up by different chemical means aimed at producing an increase in epinephrine with all its side effects In this way blood is diverted from the surface, preventing the loss of some body heat At the same time, however, there is a reduction in productive and reproductive processes because blood is diverted also from the udder, genital system, and digestive tract

Several management countermeasures can be employed Cattle in the open can be warmed by solar radiation even on fairly cold days Animals constantly housed can be helped by proper attention to insulation Poorly insulated walls and ceilings give an unpleasant sensation of cold because of the transfer of radiant energy to them from the animal body Room air at 50°F with walls at 70°F feels as warm as air at 70°F with walls at 50°F Hence if cattle are confined, good insulation will contribute materially to their comfort

Varying the composition of the feed mixture can help reduce the adverse effects of changing weather A large part of consumed nutrients fail to show up later as milk or meat Feces, urine, and gases account for a large part of the nutrients which disappear along the way

A considerable amount of energy is used to motivate the metabolic processes This energy drain (SDA) is difficult to measure As we learned in Chapters 3 and 4, the main excretory product of the SDA process is heat Hence it would seem wise to increase SDA processes during cold weather and to reduce them n the summer This is one of the things nature has accomplished by varying the thyroxin activity throughout the year When more thyroxin is formed during the winter, the nutrients are metabolized faster and heat formation increases far more rapidly than can be accounted for directly As explained in Chapter 3, a higher plane of nutrition generally leads to a higher SDA and hence to increased heat This heat, which would be a waste product during hot weather, actually can keep cows warm during the winter

In addition to increasing SDA by increased feed consumption, SDA heat can be increased quickly by varying the ration qualitatively There is an SDA for all major nutrients, but it is most pronounced in the case of *proteins* This is true especially if protein is available in excessive quantities The reason for this is that the body cannot store extra or misfit amino acids, and they are changed to sugar In this process a great deal of heat is formed But isn't excessive feed, particularly excessive protein, wasteful? It certainly is, biologically speaking at least If it will help to hold milk production at a profitable level, however, use of extra protein in this way is easily justified economically

It must be recalled also that excess protein may cause extra heat during the warm seasons At this time of year the protein must be kept as close as possible to the actual nutritional requirements Refer again to Chapter 3 for a more detailed discussion of plane of nutrition and other phases of SDA

In the winter the cow has to warm all the water she consumes and this requires considerable metabolic heat It is worthy of mentioning again that winter forage is likely to be very high in moisture Hence a cow may have to warm as much as 20 gallons of water taken in as green feed *Some benefits should be expected therefore from increasing the intake of dry matter from some other source and supplying warm water during short periods of very severe weather*

It should be remembered also that distension of the rumen by indigestible parts of rough feeds increases the animal s effective surface area and thus its heat loss per unit of body weight will be increased *Rations for use during severely cold weather therefore should be high in metabolizable energy per unit of bulk*

It seems obvious that observation of a few principles of bovine physiology can alleviate most of the problems arising from cold weather effects The problems of weather in relation to dairy production in most parts of the country do not involve keeping adult animals warm during the winter Dairy cattle adapt easily to cold weather and the application of physiological principles can prevent extreme distress when the temperature cools suddenly The most serious problem involves summer comfort of the milking herd

6 LACTATION

In chapter 1 we investigated the effects of physiological and environmental stress upon cattle as well as the importance of adjustment to stress You will recall that the survival, reproductivity, and productivity of the cow are adversely affected by improper adjustments to stress Then in Chapter 2 we developed certain physiological principles of ruminology that influence the dairy cow's capacity for adjustment Chapter 3 was devoted to how to evaluate feed, its basic components, chemistry, and energy value—the emphasis being on basic principles of nutrition that can be applied in different environmental situations In Chapters 4 and 5 the dairy cow was viewed in its natural environment, and the conditions of stress caused by hot and cold weather were considered Now we are ready to study a function of the cow that belongs to the sphere of production, i e, lactation

Although the physiology of lactation is discussed thoroughly and well in various other publications,[2,3] the student of dairy-cattle management must keep all principles pertaining to the production of milk well in mind Therefore, a brief general treatment of the principles involved is not only appropriate at this point but also highly desirable, since by such knowledge the manager is able to avoid many conditions of stress arising from lactation and thus to increase milk production

THE UDDER AND ALLIED STRUCTURES

The supporting structures of the udder are of special importance to the dairy manager because defects in this part of the system are detected fairly easily The udder's main supports are the two medial suspensory ligaments, which divide it into halves One of these tough ligaments is attached to the inner side of each half of the udder Each ligament *completely covers* its inner half, or compartment, and extends upward, where it is attached firmly to the pubic bone (Figure 6-1) The two medial suspensory ligaments are then fused together for additional support

Returning to the inner compartments, we find that from the lower end of each medial ligament, fibers extend out across the bottom of the udder

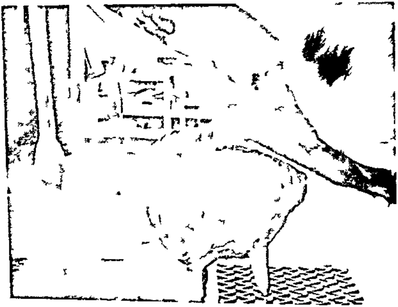
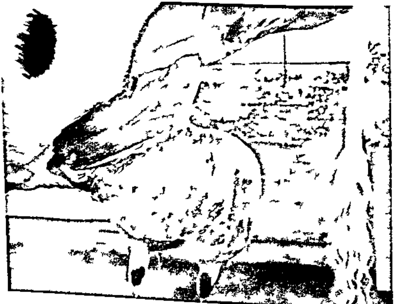


Figure 6-1 The Udder *(Above)* As seen from the left with all the supporting structures removed except a small area of skin aveolar tissues which attach the skin to the surface and which bind the front quarters to the abdominal wall and the main part of the medial suspensory ligament shown at the top mid position Note the streak of light between the udder and abdominal wall *(Below)* As viewed from the right side with the medial suspensory ligament remaining as the only support Note the almost perfectly balanced suspension (Courtesy U S Dept of Agriculture)



These fibers are fused with sheets of connective tissue forming lateral suspensory ligaments which extend around each outer side of the udder and which are attached to the body cavity Since these lateral ligaments are fastened to the medial ligaments at the bottom and to the body cavity at the top, it is easy to see that they actually form a sling for supporting the udder It should also be noted that there are connective fibers that extend at intervals from the medial and lateral ligaments on through the interior of the udder where they help support the functional tissues Thus the supporting tissues are in the form of many cradling structures which support the internal structures of the udder at all levels

The Udder Attachments

The front of the udder is reasonably close to the underline of the body cavity Strong connective-tissue fibers (fascia) extend from it to the main body tissues Cattle judges often run their fingers across the body wall just in front of the udder to determine the strength of these fibers since they constitute the main part of the front attachment

The rear of the udder is further removed from the undersurface of the body and hence must be supported by longer fibers of connective tissue The rear attachment is best when it extends quite high between the thighs and is very broad

The entire udder is supported to some extent by its skin—which is unbroken except for four openings, one at the end of each teat

Internal Structure of Udder

The udder is composed of four distinct glands, separated as shown in Figure 6-2 In most cows the front two glands produce 40 per cent and the rear two about 60 per cent of the milk

The gross internal udder structure is shown in Figure 6-3 The opening at each teat (*streak canal*) is about ⅛ of an inch in length and is held closed by a band of muscle (*sphincter*) This leads to an open area in the teat (the *teat cistern*) Just above each teat there is another cavity known as the *gland cistern* From the gland cistern eight to twelve main milk ducts, supported by connective tissue, lead upward The main ducts branch off to many smaller ones, and this branching continues as the duct system is traced upward Thus thousands of tiny milk ducts collect secretions which make up the daily milk output

Each of the four glands is divided into lobes which are subdivided into a large number of lobules separated by connective tissue This type of structure is illustrated in Figure 6-4 Each lobule is made up of many hollow structures known as *alveoli*

Alveoli The alveoli are microscopic, balloon-like structures each composed of a single layer of epithelial cells (Figure 6-5), similar to other

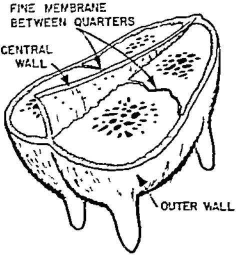


Figure 6-2. The central suspensory membrane divides the udder into distinct halves. Very thin membranes divide the halves into quarters. (Courtesy Babson Brothers Co.)

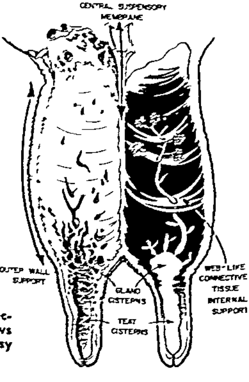


Figure 6-3. An udder cross sectioned through the rear teats shows the suspensory tissues. (Courtesy Babson Brothers Co.)

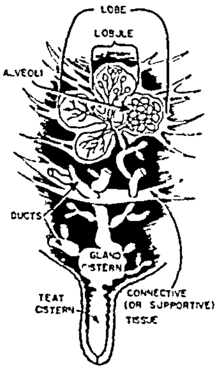


Figure 6-4. A complex duct system connects each teat to millions of alveoli. Alveoli make up lobules which in turn make up the lobes of each quarter. (Courtesy Babson Brothers Co.)

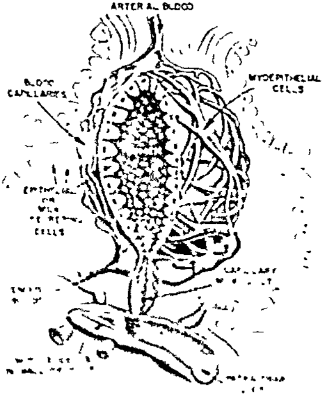


Figure 6-5. An alveolus showing secretory cells and allied tissues. (Courtesy Babson Brothers Co.)

epithelial cells Each cell contains a nucleus surrounded by cytoplasm Each alveolus is in intimate contact with a rich blood, lymph, and nerve supply, and is covered with fibers of smooth muscle

Milk constituents are taken from the blood and made into milk by the alveolar epithelial cells, whence the fluid is discharged into the interior opening (lumen) of each alveolus where it stays for the most part until the time of milking

THE BLOOD SUPPLY

Blood is supplied from the heart to the udder via two large arteries, one coming down on each side and supplying half the udder These pudic arteries in turn divide, thus making four rather large vessels, each of which supplies one quarter By branching many times (Figure 6-6) the blood is dispersed through a very large number of tiny capillaries which supply the alveoli After passing through the alveoli, the blood flows into venous capillaries of about the same size as those carrying arterial blood These converge into larger and larger vessels which finally empty into a large U-shaped vein at the upper part of the udder This collecting vein is known as the "venous ring" Four main veins lead from the venous ring—two parallel to the arterial system leading to the heart and two extending forward and entering the body cavity through openings in the abdominal region The latter two are known as "milk veins" and the openings through which they pass into the abdominal region are called "milk wells" Since it is known that *two systems* of veins are functional, the value of prominent milk veins and wells becomes somewhat doubtful as a criterion of the productivity of the cow, so that just two points of the official score card used in judging dairy cattle are allocated to the prominence of these two structures

MILK FORMATION AND PERSISTENCE

Now that we have considered the structure of the udder where the milk is contained and the structure of the vessels which carry the blood supply as well as that intermediate and transitional area, the alveoli, we are ready to discuss the constituents of milk and those endocrine functions relevant to its formation and persistence

The formation of milk by the alveoli occurs by chemical and physical processes Simple filtration accounts for some of the transfer through the alveolar wall but many of the lactation functions are controlled through life processes of the alveolar tissues

Hormonal Control

At this point a discussion of endocrinology would be helpful, but detailed descriptions, lengthy and often controversial would be involved Therefore,

No doubt the *initiation* and *maintenance* of lactation are controlled by a balance of many hormones and other factors. Injections of growth hormone have more effect than similar doses of thyrotrophic hormone, ACTH, or prolactin.

Milk Constituents

Protein. There is protein in both blood and milk, but fractions of the two are quite different. Hence it appears that some milk proteins are synthesized from amino acid residues as they pass through the walls of the alveoli, while others come through intact.

Previously the proteins of milk were classified as casein, lactalbumin, and lactoglobulin. These designations no longer suffice, however, since modern protein chemistry shows that each of the above substances is made up of various fractions. Thus there are at least three caseins (alpha, beta, and gamma) and possibly a fourth. These account for about 80 per cent of the milk proteins.

The classical lactalbumin and lactoglobulin are known as "milk serum" and "whey" proteins, since they are the residual products of cheese making. Lactalbumin now is fractionated into alpha albumin ("blood serum albumin") and beta lactoglobulin. The last probably is composed of two subfractions, beta$_1$ and beta$_2$ lactoglobulin. In addition, two fractions have been found in classical lactoglobulin, i.e., the gamma globulins with which immune bodies are associated, and the pseudoglobulins.

Sugar and Fat. Milk sugar, or lactose, likewise is synthesized by the alveoli from constituents derived probably from glycogen and possibly from blood sugar (glucose). Except for a few rare instances in plants, lactose has been reported as occurring only in milk.

Milk fat no doubt is synthesized, at least partially, by the lactation tissues. Acetates resulting from bacterial action on fibrous feeds are precursors of many of the fatty acids, the other milk-fat constituent, glycerol, comes directly from the blood.

Fat synthesis appears to be independent of the lactation process as a whole. Thus the rate of fat lactation appears to be affected markedly by udder pressure. The last portion of each milking is much higher in fat than the first, perhaps because udder pressure prevented the fat's filtering through the secretory cells. Of course, it is also possible that fat simply tends to stay at the top of the udder longer because it is the lightest part of the milk. Nevertheless, when milk production drops suddenly the total fat production stays about the same or decreases more slowly, indicating that its formation is separate.

Drastic reductions in the *fiber content* of feed can affect fat lactation very quickly During droughts or floods, when leafy feeds were restricted, tests showed reductions in fat by as much as half within a few days

Mineral Matter. Mineral matter enters the milk by a process known as "selective filtration " It is not simple physical filtration but a vital cellular function, since minerals in milk and blood occur in different ratios While there is approximately 14 times as much calcium in milk as in blood, 7 times as much phosphorous, and 4 times as much magnesium, there is only one quarter of the chlorine and one eighth of the sodium in milk that is normally found in blood Yet the osmotic pressures of milk and blood are equal

Other Constituents. Associated with the fat are phospholipids (mainly lecithin), Vitamins A, D, E, and K, cholesterol (the precursor of Vitamin D), and various pigments including carotene, which is responsible for most of the yellow color of milk and is the precursor of Vitamin A These fat-soluble vitamins and pigments come through unchanged from the blood, and the quantity of all but Vitamin K in the milk varies with their levels in the feed Vitamin K and the B-Complex vitamins are synthesized in the rumen, and Vitamin C is formed in the body tissues Therefore, if the feed is adequate in other respects, the milk will be normal in content of these vitamins whether they are available in the feed or not All vitamins and water are filtered directly from the blood into the milk The water in milk serves a very important function as a vehicle for the solids, some of which are in solution while others are in suspension

Enzymes which affect flavor and keeping qualities are found in milk Lipase can cause the breakdown of milk fat, particularly when the milk is agitated unduly Such enzymes as galactase, lactase, oleinase, diostase, oxidase, peroxidase, catalase, phosphatase, and various others affect proteins, sugars, and starches and may change the acidity and flavor of milk considerably

Volatile flavors, such as those of *silage* or of certain *weeds*, travel from the blood to the milk simply by filtering through the alveolar wall These substances are removed from the blood rather rapidly, however, through the urine and breath When enough have been removed in this way so that concentration in the milk is higher than in the blood, the filtration proceeds in the opposite direction until the milk is untainted Approximately two hours are required for most feed flavors to reach a maximum in milk and about another hour for them to be dissipated by the body Hence two hours before milking is the worst time to feed such roughage *But if the cows are removed from volatile flavor-producing feeds three hours before milking, usually no unduly feed-flavored milk results*

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THE MILKING PROCESS

The Milking Routine

Milking practices should follow an established pattern which must be a pleasant one for the cow

Hand and Machine Milking Milk can be removed from the udder by applying pressure The teat is grasped between the thumb and forefinger shutting off the opening to the gland cistern Then by applying pressure with the other fingers the milk is *forced* from the teat cistern through the streak canal Releasing the pressure allows the teat cistern to fill again and the process is repeated

The milking machine does not squeeze milk from the teat It *draws it out by vacuum* in much the same way that a nursing calf does In addition to sucking however the calf massages the teat thus preventing congestion The machine also must promote health of the udder and remove the milk quickly and completely The manner in which this is accomplished by the machine is discussed fully on page 58

Role of Hormones At each milking the hormone oxytocin secreted under the stimulation of the milking routine plays and indispensable role It causes the muscle fibers around each alveolus to constrict thus forcing the milk from the lumen into the ducts which oxytocin also affects causing them to straighten and enlarge While this hormone is in operation the milk is forced into the lower ducts and gland cistern *Thus when the cow is handled properly nature does more of the milking than does the machine*

Another hormone mentioned earlier (epinephrine see Chapter 5) works against nature to a greater extent in the milking process perhaps than anywhere else This hormone which is secreted into the blood whenever the animal is frightened angered or made uncomfortable causes blood vessels to constrict This applies especially to that part of the vascular system supplying the peripheral parts of the body including the udder Thus though plenty of oxytocin for normal milk letdown may have been secreted it cannot get through the restricted blood vessels to the alveolar tissue in amounts sufficient to affect the milk secreting tissues Both these hormonal actions can be triggered by the conditioned reflex as explained in Chapter 1 As mentioned previously pleasant milking practices are essential

Milking Frequency

As milk is formed pressure builds up in the udder and slows the process When the pressure of milk in the udder reaches 25 to 40 millimeters of mercury lactation stops since this is about equal to capillary blood pressure Hence the more frequently milk is removed the greater the aver

age differential between blood and udder pressures will be, and the faster milk will be formed There is considerable individual variation, of course, but cows milked once rather than the usual twice daily yield only half as much

Milking three times daily yields 15 to 20 per cent more than twice-a-day milking Cows milked four times daily produce 25 to 30 per cent more than those milked twice Usually this extra milk is not worth the added expense, but at times it could be if an increase in yield is particularly desirable

The Milking Interval

The milk-blood pressure differential influences the milking interval for regular twice-a-day operations For the very highest production, a 12-hour interval keeps pressures lowest and could be important if the very highest yield possible were desired, as in the case of record-making purebred animals For many herds, however, the interval can be arranged to some extent for convenience Milking at intervals of 10 and 14 hours gives practically the same results for most cows as at two 12 hour intervals[1] Since average production records are increasing rapidly, the milking interval should be watched, adjustments, at least during base periods, may be worthwhile

Drying Off

In order to maintain the ability to produce at high levels, good cows must have a vacation during which no milk is formed and reserves can be replenished The process by which they are caused to stop producing milk usually is referred to as "drying off"

When it is desirable to dry off a cow, in most cases milking is stopped abruptly and the udder pressure stops the lactation When excess pressure occurs, occasional milking or drastic feed reductions to help stop the process, may be practical However intermittent or incomplete milking may be harmful Milk allowed to remain in the udder causes intramammary pressure to increase rapidly and inhibit the formation of milk

Fresh, normal milk contains lysozome, a bacterial inhibitor Milk left in the udder loses lysozome activity, however, and bacterial growth may increase for a time Later, as the blood and milk pressures stabilize, fluids which cross the alveolar wall become similar to blood serum These fluids contain little casein, lactose, or fat, but are rich in globulins and albumin Thus, immune bodies and/or leucocytes which filter through suppress bacterial activity

If the cow is milked after the composition changes, the udder is exposed unduly to danger of infection, since the secretions must go through

similar changes all over again before establishing a natural defense To complicate the situation further, milking is likely to stimulate production of the lactogenic hormone(s) and thus stimulate lactation Yet, when structures of the udder are known to be weak, intermittent milking may be practical if used with caution No one system is always right, constant attention is necessary, and a separate decision is essential each time a cow is dried off

THE MILKING EQUIPMENT

The milking system may include pails into which the milk from each cow is collected separately This has many advantages since the milk from a single animal can be inspected, weighed, and sampled individually with no additional attachments In many dairies, however, the milk is drawn from the cow through pipelines directly to the cooling tank The saving in labor has made this system popular Sampling and weighing devices can be incorporated into the pipelines or pails can be used periodically for purposes of production testing

Whether pipeline systems or individual milking machines are used, the mechanism is the same There are two parts to the vacuum milking system In one, a vacuum can be applied continuously to the teats Thus when the udder is under the influence of oxytocin, milk removal could be continuous, but milking isn't done this way, because a single, direct vacuum, if applied continuously, would trap lymph and blood in the lower parts of the teats Severe inflammation would result quickly, so the second vacuum component is used intermittently to massage the teats (Figure 6-7)

This is accomplished by using a rubber liner inside a rigid teat cup Continuous vacuum causes this to collapse around the teat, thus stimulating the flow of vital fluids, as shown in Figure 6-8 No milk flows at this time Intermittently the liner is caused to snap open when vacuum is applied between it and the shell Then milk flows while the liner is open, and stops for the most part when the teat is squeezed again by the massaging liner This may seem to be the reverse of what occurs in good hand-milking, but the principle of massage and alternating pressures is the same

Pulsation

Various machines operate at pulsation rates of 40 to 120 cycles per minute The complete cycle includes both collapsed and expanded phases The pulsation ratio expresses the relation of the phases If the ratio is 50 50, the inflation is collapsed half the time In general, the longer the expanded phase is, the faster milk will flow Most machines have employed a 1 1 ratio, but new ones now use ratios as high as 2½ 1 and with as many as 60 cycles per minute Thus the milking phase has been increased 42 per

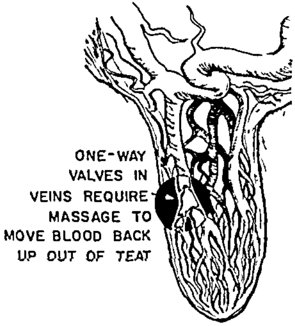


Figure 6-7. The circulatory system of an individual teat. (Courtesy Babson Brothers Co.)

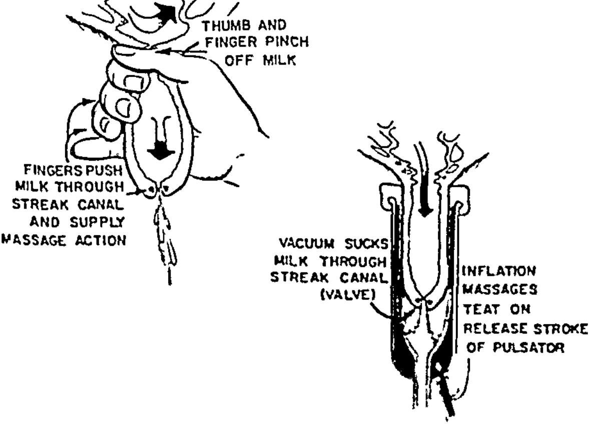


Figure 6-8. Two ways to remove milk from the udder. (Courtesy Babson Brothers Co.)

cent Faster milking is needed now because productivity of cows has increased about 58 per cent during the last 17 years although milking rates, until recently were not changed appreciably to correspond with the increase

The vacuum level is as important as any other feature of the equipment It varies from 10 to 16 inches of mercury in most machines Although most cows can be milked faster with high than with low vacuum the danger of congesting the udder increases with high vacuum Nevertheless milking-machine manufacturers have now coordinated mechanical factors to give the fastest milking rates with the least danger

Care of the Equipment

Milking equipment often is the only farm equipment used twice every day in the year Much of it is precision made, and the best of materials are used throughout All milking equipment is relatively expensive Yet often it is the most neglected and least understood implement on the farm In the case of slow milking uneven milking or irritated teats, usual malfunctions are as follows

A Slow Milking

(1) An inflation may have burst This trouble is detected easily because leaking inflations usually cause a hissing noise

(2) Inflations may be stretched The useful life of rubber inflations can be extended many times by keeping two sets and alternating them at weekly intervals The set not in use is stored dry in a refrigerator The cold reconditions and restores elasticity to the rubber (Figure 6-9) Another method is to store the alternate inflations in a cold lye solution during the recovery week This system works well in softened water but it should not be attempted with hard water because the inflations will become coated with mineral matter which is very difficult to remove Plastic lined metal containers serve as inexpensive and convenient repositories for cold lye storage of rubber The lye should be mixed in another container however since the heat of solution will melt most plastics

(3) Vacuum may be too low

(a) The belt between motor and vacuum pump could be slipping due to wear or improper adjustment

(b) Oil in the vacuum pump may be too low These items should be checked routinely

(c) Vacuum line could have a leak

(d) Air hoses or operating covers may be leaking These malfunctions are accompanied by a hissing noise

(e) Vacuum pump may be overloaded This often occurs when units are added after a barn is built

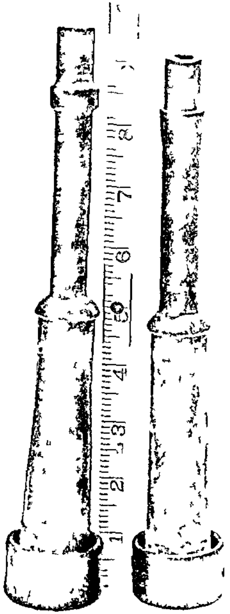


Figure 6-9. Refrigeration keeps rubber pliable and elastic. Note effect of one week's storage in cold on inflation at the right.

(f) Vacuum line or hoses may be plugged (they should be thoroughly cleaned at least once each week, even though nothing but air supposedly goes through them)

(g) Pulsators may be set too fast, on some machines this is adjusted automatically Hand adjustable pulsators must be checked as a routine part of the milking process

B Uneven Milking

(1) One or more of the inflations may be leaking or excessively worn A supply of replacement inflations must be kept on hand

(2) Teat cups may not be properly attached to the cow This could cause udder injury also

(3) Air hose may be leaking This could happen at any time Hence a supply of a r hoses must be kept on hand

(4) Teat may be malformed or injured Such cows must be milked by hand o d sposed of

C Irritated Teats

(1) Machine may be left on too long It must be removed as soon as the milk flow stops

(2) Machine may have been pulled off without breaking vacuum To release the vacuum push in on the udder above a teat cup thus allowing air to enter the system

(3) Pulsator may be set too slow

(4) Pulsator may have stopped due to failure of the mercoid switch on equipment using this device

(5) Pulsator may be damaged or worn out

(6) Pulsator may be blocked by dirt or hair

(7) Vacuum may be too high

(a) Vacuum regulator may be stuck it should be inspected and cleaned at regular intervals

(b) Pump speed may be too fast

Alertness to detect minor malfunctions in the systems of milking ma chines and the ability to remedy them will save many service calls and promote the health of the cows

7 FORAGE CROPS

ALTHOUGH THE TERM "ROUGHAGE" USUALLY MEANS FORAGE, IT HAS been employed to describe various other types of feedstuffs Thus citrus pulp, beet pulp, ground snapped corn, dried brewers grains and the like, often are called "roughages" because of their bulk Perhaps it is better to think of these products simply as bulky concentrates

On the other hand, such materials as peanut hulls, cottonseed hulls, and ground corn cobs do have more characteristics of roughage than of concentrates, and are so used Such feed can be practical, but their deficiencies in essential nutrients and precursors are obvious

For the purpose of this discussion, unless specified differently, the term "roughage" will apply to leaves, stems, and whole plants Most roughages are utilized in the form of pasture, greenchop, hay, or silage Fresh green *forage*, often called *herbage*, is without question the best dairy cattle roughage available

FACTORS AFFECTING QUALITY AND PRODUCTION

Prior to any discussion of the uses of forage, the general factors affecting the quality of herbage and its production will be presented These factors are as follows the forces of nature, the type of soil and its fertilization, the type of plants growing in the herbage, and pasture renovation

The Forces of Nature

The forces of nature affect animals and plants in much the same way In fact at this point, and in this respect, students are likely to find it difficult to explain the difference between plants and animals For example it was mentioned previously in connection with animals that the strongest of nature's impulses is survival, the second strongest being reproduction The same is true for plants in that each species must continue itself and requires nutrients for the maintenance of life However plants are markedly different in certain respects Plants do not use locomotion for food getting, but instead have a method of manufacturing food (photosynthesis) from raw materials Thus by the utilization of the energy of the sun in the pres-

ence of chlorophyll the green plant is able to synthesize food from the *carbon dioxide* of the atmosphere and the *oxygen* of water. In addition if the plant is to be healthy the soil in which it grows must be of such a quality as to provide the necessary *minerals*. By the choice of proper fertilizers and by the use of techniques of pasture renovation the manager can do much to insure soil quality.

It should be the object of the manager to make the most of the primal characteristics of plants in obtaining nutrients for cattle. To do this he must not only understand the fundamental nature of the green plant but also the fundamentals of plant development. In plants almost all of the storage occurs in the leaves. When environmental conditions are favorable, leaves develop rapidly. Under very good conditions some improved varieties seem to consist almost entirely of leaves. They were bred for this characteristic which makes them nutritious to herbivorous animals.

The best stage of growth for forage is limited to a relatively short time. As soon as sufficient nutrients accumulate in the leaves, reproduction begins by the formation first of stems then of seeds. This process takes protein from the leaves and puts it in the seeds, but a considerable part of it is lost in the process. The stems which are made at the expense of protein and nutritious carbohydrates are composed largely of fiber. Therefore from the standpoint of the total plant, maturity results in *decreased protein* and *increased fiber* content. *The animal manager must use forage plants while they are in the most leafy stage, thus obtaining for use by the cow the greatest number of nutrients manufactured and stored by the plant.*

Under harmful conditions even the best forage plants become fibrous. The leaves curl, growth is slowed and reproductive processes occur prematurely. As the plant toughens itself there is an increase in fiber content and a decrease in proteins, thus nutrients are being depleted. In fact, plants exposed to unfavorable conditions rapidly take on the characteristics of aging. Proper conditions of soil fertility light moisture and temperature are necessary to the production of nutritious plants (those with an abundance of leaves in a tender high protein state).

Type of Soil and Its Fertilization

Although good forage depends upon favorable environmental conditions in general, the soil is of special significance because of the scientific progress man has made in his knowledge of soil and its fertilization. The scope of this book does not permit a lengthy discussion of soil at this stage however, this information is available in many sources.

The fertilizer requirements of a specific soil can be determined only by soil testing. Nevertheless, some general statements apply to fertilizer management of all soils. Clay soils usually are high in copper. Red clay is very

high in iron—so much so that at times extra phosphorous is required White and gray soils often are lacking in iron, copper, magnesium, manganese, and possibly other minor elements This is important when such crops as alfalfa or clover are planted

Occasionally, deficiencies or excesses fail to show up in quantitative pasture production, but have drastic effects on grazing animals An example is peat soils, which are very high in molybdenum Plants grown on this type of soil are healthy, but cattle consuming them become anemic from molybdenum poisoning unless extra copper is supplied as a supplement

Type of Plants

Another factor influencing quality and production is the type of plants growing in the forage Combination legume-grass swards are important because in combination they are utilized more completely by grazing animals than when fed separately However, there is a problem of balance between grass and legume growth For example, nitrogen fixation by the legume promotes growth of grass, but overreliance on this function results in suboptimum total forage Yet, nitrogen must be applied with care Let us elaborate *Initial* application of nitrogen to mixed swards often

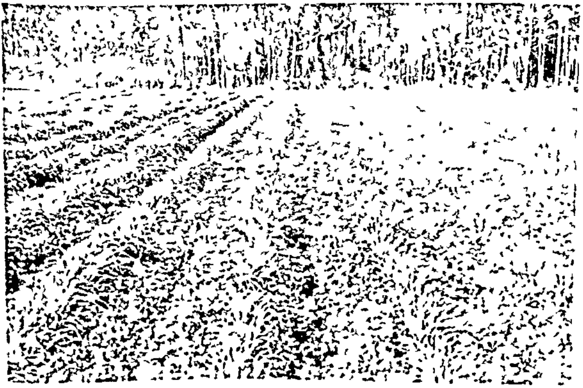


Figure 7-1. A method of minimizing competitive suppression. The oats were planted in rows and the alfalfa was broadcast.

causes a *desirable increase* in the yield of dry matter which is derived from the extra growth of grass. However, at the same time, legumes are inhibited and may recover slowly. Thus when nitrogen is applied *continuously* there is a tendency for the legumes to be crowded out by the extra growth of grass.[2] This can result in a *decrease* of dry matter in the *total* forage. In the case of a legume-grass sward, the obvious answer is to supply a balance of fertility for both plants.

We will digress for a moment to point out that this type of competition is not serious with most permanent pastures because usually the growing seasons of legumes occur at different times of the year from the grasses. Clover for example grows mainly during the spring, whereas grasses of a permanent nature achieve most of their growth during the summer.

On the other hand, competitive suppression is a particularly serious problem when cereal crops are planted in combination with clover and alfalfa for temporary winter or spring grazing. Competitive suppression in this case can be lessened considerably by *drilling or broadcasting the legume and planting the grass in rows* (Figure 7-1). The fact that *continuous* nitrogen fertilization promotes grass and suppresses clover in mixed swards in which both plants grow for the most part at the same time is shown by the data in Table 7-1.

Grass herbage when grown alone responds to nitrogen fertilization by improved production (Table 7-2) and improved digestibility of protein (Table 7-3).

Pasture Renovation

Renovation may consist of procedures varying from harrowing to a depth of a few inches to deep pulverization by power driven rotary tillers followed by soil testing, fertilizing, and planting with recommended forages. Renovation is suited particularly to sandy, wet, rocky, or hilly areas. It improves aeration and water holding capacity by modifying the structure of the soil.

Under continuous grazing systems unimproved soils support mainly low-growing, fibrous grasses and broad leaved plants. The grazing season is usually short and the carrying capacity low. Renovation generally results in an extension of the grazing season, with carrying capacity comparable to that of tillable fields.

In many cases frequent disking, use of chisel tooth cultivators or other scarifying tools, frequent mowing and adequate fertilization are all that is needed. At times, however, the native plants are too well established to be replaced by improved swards in this way. Then it is desirable to use a herbicide to reduce competition. Many selective weed killers are available the use of which depends largely upon local conditions.

Of course soil structure and texture determine largely the type of plants

Table 7-1. Output of Dry Matter (D.M.) and Crude Protein (C.P.) from Grass-Clover Plots Receiving Dressings of Nitrogen Fertilizer

	Period	Nitrogen (lbs/acre/year) 0	35	70	140	210	350
Yield of herbage (cwt D.M./acre/year)	1950	44.0	54.2	59.3	73.6	82.1	98.6
	1951–55	58.6	60.2	61.6	68.2	78.2	92.6
Herbage yield increase (lb D.M./lb N applied)	1950	—	32.6	24.5	23.7	20.4	17.4
	1951–55	—	5.1	4.8	7.7	10.4	10.9
Yield of crude protein (cwt D.M./acre/year)	1950	5.5	6.5	6.8	8.9	11.2	13.9
	1951–55	10.1	9.9	9.3	10.1	11.3	16.6
Crude protein yield increase (lb C.P./lb N applied)	1950	—	3.2	2.1	2.7	3.0	2.7
	1951–55	—	−0.6	−1.3	0	0.6	2.1
Yield of clover (cwt D.M./acre/year)	1951–55	21.3	17.1	12.9	4.8	1.0	0.3
Percentage clover D.M. in total herbage D.M.	1951–55	36.3	28.4	20.9	7.0	1.3	0.3

Table 7-2 Effect of Rate of Nitrogen Application on Dry Matter Production and Protein Content of Grass Herbage, Pennsylvania, 1955–58

Nitrogen applied, (lbs/acre)	Dry Matter (tons/acre)			Protein Content (%)		
	Timothy	Orchard-grass	Kentucky Bluegrass	Timothy	Orchard-grass	Kentucky Bluegrass
0	1.31	1.03	1.05	8.9	10.5	11.6
50	2.56	1.70	1.64	8.2	11.6	12.4
100	3.05	2.07	2.12	9.7	13.9	13.7
200	2.99	2.55	2.65	12.2	17.9	17.4
200 split 100/100	3.88	2.63	2.86	10.5	15.9	16.2

and cultivation practices that are most feasible. A soil is composed of various *sizes* of particles that determine its *texture*. Such descriptions as gravelly sands, coarse sands, and fine sands indicate the texture of light soils, i.e., they are well aerated but have little water-holding capacity. In contradistinction, the heavy soils (sandy clays, silty clays, and gravelly clays) are poorly aerated but high in water-holding capacity. The loams (silty loams, sandy loams, and clay loams) are intermediate. Aeration is better than in heavy soils and water holding capacity is superior to that of light ones.

The *arrangement* or grouping of particles determines the *structure* of soil. This is as important as texture and is more easily controlled. In fact, the changes which occur as a result of renovation and cultivation are for the most part structural, thus drainage, heat exchange, aeration and compaction are regulated.

In general it is true that new legume plantings need inoculation and that more inoculant is required with light than with heavy soils. However care

Table 7-3 Effect of Rate of Nitrogen Application on Nutritive Value of Forages, Pennsylvania, 1958–59[2]

Forage	Nitrogen (lbs/acre)	Harvest Date	Digestibility (%)			Digestible Energy (cal/kg of dry matter)
			Dry Matter	Protein	Energy	
Orchardgrass	50	27/5	69.9	64.0	65.9	2919
Orchardgrass	100	23/5	69.7	71.3	65.7	2962
Orchardgrass	200	21/5	70.5	76.4	66.6	2997
Orchardgrass	300	21/5	73.1	79.8	68.7	3092
Orchardgrass–alfalfa	0	27/5	69.6	72.6	67.3	3009
L.S.D. 0–05			1.8	4.5	2.2	

must be exercised in the matter of inoculation When old plants have been killed with herbicides, the rate of reseeding required is about twenty per cent higher than is necessary for plowed fields On the other hand, a combination of herbicide and surface tillage often results in more and better forage than the use of either one alone In newly developed pastures planting a series of annuals for a few years before establishing a permanent sward often promotes desirable soil structures

SYSTEMS OF USAGE

Forage may be used as pasture, or as greenchop, depending on the relative economies of the two systems *Pasture*, of course, is simply the fresh uncut forage, whereas *greenchop* is what the name implies, i e the freshly harvested herbage

Greenchopping

Circumstances under which zero grazing (greenchopping) often is beneficial are as follows

(1) Large herds Large numbers of animals are difficult to handle on pasture Time is saved and more individual attention is possible when the cows are confined in groups according to production, and the leafy roughage is brought to them
(2) Some dairies are on very high-priced land and the grassland operations must be as intensive as possible Usually, more forage can be obtained by greenchopping than by other methods
(3) When forage is in short supply, it can be rationed to cows in proper amounts by confinement feeding
(4) Often modern dairies are situated on land which is not suitable for grazing Greenchopping on a large scale results in high milk yields per acre with no deleterious effects on milk quality or health of the cattle

It should be pointed out that daily provision of high quality greenchopped forage requires more skill than the use of other systems Dairymen who are not utilizing their pastures efficiently should consider other methods Efficiency can be enhanced more easily by an increase in stocking rates Rate of stocking will be discussed in more detail later in this chapter under Special Aspects of Pasture Management

Dual Usage

At times both greenchop and pasture are used A good example of dual usage was mentioned in Chapter 4 as a means of preventing the summer slump of milk production Since during the summer cows do most of their

grazing at night they are turned onto pasture at that time and are fed greenchop in a shady area during the day Many methods of harvesting and transporting the forage are in use

Use of Pasture Grazing Methods

Although adequate use of pasture involves a consideration of the total management picture there are certain basic grazing methods with which any student of dairy cattle management should be familiar These are rotational grazing selective grazing and strip grazing

Rotational Grazing Rotational grazing involves the use of three to six plots successively Its purpose is to insure utilization of most plants As the growing season of the herbage moves into the fastest growing stage managerial problems may occur i e before one plot is grazed sufficiently the next is likely to be ready The manager must watch the first plot in the series and move the animals back into it at the proper time The other lots which are mature at that time can be chopped for preserved forage

Selective Grazing The Hohenheim system of grazing published in 1926 by the Ministry of Agriculture of Great Britain stressed the qualitative value of selective grazing Modern procedures have reinstated the practice in many areas In this type of grazing the highest producing cows are employed first so the cows select the choicest part of the herbage Dry cows and heifers then are allowed to clean the pastures

More recent experiments conducted by Pieper *et al* have shown that when selective grazing is possible the part selected by the cows first is the forage which is highest in digestible dry matter nitrogen and crude fat and is lowest in fiber Table 7 4 shows the effect of top (first choice) and bottom (the clean up phase) grazing on milk production per head

Heavy stocking rates or greenchopping when the animals are given only the forage which they will clean up insures optimum utilization This gives the best yield of milk per acre but it causes a decrease in individual output from all really good cows Dry matter digestibility was observed to be higher for top than for bottom grazed forages as shown in Table 7 5 [1]

Strip Grazing This method makes different parts of the pasture available at different times Thus strip grazing is a movable system whereby cattle are *limited* to one particular grazing strip in a pasture Clearly the basic concept of strip grazing could create certain problems For example shutting the cattle into very small spaces on the pasture could necessitate the prevention of excessive exposure to the sun (especially if the summer conditioning of cattle is questionable) because natural shade seldom is available over an entire field Moreover the water supply can be very important since water can easily be the limiting factor in milk production Also unless the strip-grazing setup is devised properly access to the cattle

Table 7-4. Milk Produced by Cows Grazing Top and Bottom Herbage of Two Pasture Mixtures, 1957, Middleburg, Virginia

	Growth Grazed by Dairy Cows			
	Top		Bottom	
	Grain*	No Grain	Grain*	No Grain
(1) Standardization period All cows fed 16% protein feed at the rate of 1 lb/6 lbs milk, for a 28 day winter feeding period before the experiment started.				
(a) 4% milk per cow daily during this period (lbs)	42.6	41.2	43 0	42.2
(2) The cows then grazed top or bottom growth of orchardgrass-Ladino clover pasture for 49 days.				
(a) Lbs milk daily**	44.4	42.9	39.9	30 5
(b) Relative to standardization period	104	104	93	72
(3) The cows then grazed alfalfa-orchardgrass mixture for 70 days.				
(a) Lbs milk daily**	39.7	32.4	33.8	21.8
(b) Relative to standardization period	93	79	79	52
(c) Lbs milk daily for the last 14 days**	34.4	27 6	25.0	14.2
(d) Relative to standardization period	81	67	58	36

*Ground shelled corn was fed at the rate of 1 lb to each 8 lbs of milk (4% fat)

**There were significant differences between treatment means ($P < 0.01$).

for supplemental feeding and attention would be difficult Therefore, on most farms the strip-grazing setup is devised so that shade, water, mineral boxes, fence controller, hay or other supplemental roughage, and access to the cattle are available in one corner of the pasture In short, the system is

Table 7-5. Dry-Matter Digestibility of Ingested Herbage for Steers with Top-, Bottom-, and Whole-Plant Grazing on Nitrogen-Fertilized Grass Pastures, Middleburg, Virginia, 1959*

Sampling Cycle	Rotational Grazers		
	Top (%)	Bottom (%)	Whole Plant (%)
	Orchardgrass-nitrogen-fertilized		
April–May	71.7	65.6	68.0
June–July	70.5	65.8	66.2
Aug.–Sept.	60.6	54.4	58.8
	Tall fescue-nitrogen-fertilized		
April–May	70.0	62.0	68.2
June–July	68.3	64.9	63.1
Aug.–Sept.	60.7	55.7	58.0

*The mean difference for type of grazing and dates were highly significant.

so contrived that no matter which strip the cattle are limited to they always have access to the same service area for such purposes as shade drinking water etc (see area 5 in Figure 7 2) This should be the corner nearest to the barn unless considerably better drainage and natural shade are avail able elsewhere

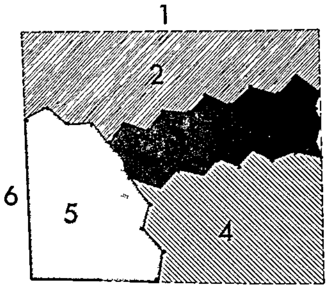


Figure 7 2 Organization of a system for strip grazing (1) permanent or electric fence or open (2) area which has been grazed (3) area being grazed (4) area to be grazed (5) service area (6) perma nent or electric fence

Electric fencing materials and methods wh ch are d scussed in detail at the end of this chapter are useful in strip grazing Portable fences employ ing l ghtwe ght posts with sharp po nts or tripods are popular because they are easy to install and move to various locations Cattle learn qu ckly that contact with the charged wire is very unpleasant They w ll graze right up to it and even reach under the fence Even very light wires will keep them in a des red area however after being trained to the electric fence The fence controller s attached at one corner of the field allowing just the amount of wire needed for charg ng It modifies the imput power by in creas ng the voltage reducing the amperage and by making the output interm ttent The arrangement shown in Figure 7 2 is poss ble because there is only one charged wire lead ng from the controller This wire is run from the corner around one side of the service area across the pasture around the perimeter of the area to be grazed and then back to and

around the other side of the service area, as shown in Figure 7-2. Thus grazing animals have access to the entire service area but are limited to the part of the pasture which is in the best stage for feed.

Sprouted Grains

Still another system of fresh herbage feeding is now in limited use. This involves sprouting grain in soil-less cultures Temperature, humidity, and plant nutrients are controlled carefully in special structures for this system. Although equipment is expensive, no farm machines are required, and a new crop is produced each week

Various experiments have shown that sprouted grains can be useful, but they cannot take the place of regular herbage because cattle usually will not eat enough. The sprouting process causes a loss of dry matter (dry matter contains all the energy-bearing nutrients) and does not appear to impart any special properties for stimulation of production or reproduction processes in the cow Still, the value of a constant source of green feed may be considerable

While merely sprouting the grains definitely causes a loss of nutrients, the possiblity of growing the plants in a culture high in nutrients needs further study. Most systems using the hydroponic principle now produce a harvest only one week from the time the seeds are placed into the culture. Thus it appears that the plants are being removed at just about the time that rapid nutrient storage is beginning Many questions which are pertinent to the economics and techniques of hydroponic forages remain unanswered at present

Forage utilization by some systems appears to be an inseparable part of most methods of dairy cattle management This is a complex problem which must be solved separately for each operation Any solution should be based on principles which consider the functions of the ruminant digestive system, conservation of adaptive energy, and the effects of feed on milk composition as well as cost factors Conventional methods of grazing, greenchopping, and use of preserved forage singly or in combination appear to be practical for most areas at present

Use of Mixed Roughages

In some sections roughage mixtures which can be handled as concentrates have become very popular In general, concentrates are defined as seed and plant by-products which are relatively high in energy and low in fiber content Such roughage mixtures usually include enough chopped hay to increase bulk and thus insure normal rumen action Other ingredients used for these purposes are dried citrus pulp, dried brewers grains, and ground snapped corn which includes the cob and shuck Since these

are high quality feedstuffs a roughage mixture which contains them can support production at high levels Some low nutrient feeds such as cotton seed hulls and ground corn cobs also are used Although these do no harm and possibly help when employed in small amounts, they occupy too much rumen space for too long when used in large quantities Thus the producing ability of the cow may be limited by lack of room for consumption and digestion of adequate concentrate feeds

There are two other features to watch when mixed roughages are used extensively As previously mentioned such ingredients do not contain the pigments vitamins and minerals that usually are in roughages of a leafy nature There also is the possibility that rumen fermentation of mixed roughages which contain many bulky-concentrate ingredients will cause the acetic propionic acid ratio in the rumen to narrow to a point which could result in abnormal milk, since butterfat is made at least in part from acetates formed by fermentation in the rumen On the other hand some narrowing of the ratio between acetates and propionates may be helpful, since the latter appears to have a lower SDA It may be possible also to add buffers which will prevent abnormal milk from resulting from the high propionate levels Sodium bicarbonate has been suggested for this purpose When feasible economically a combination of leafy roughage and mixed roughage merits consideration

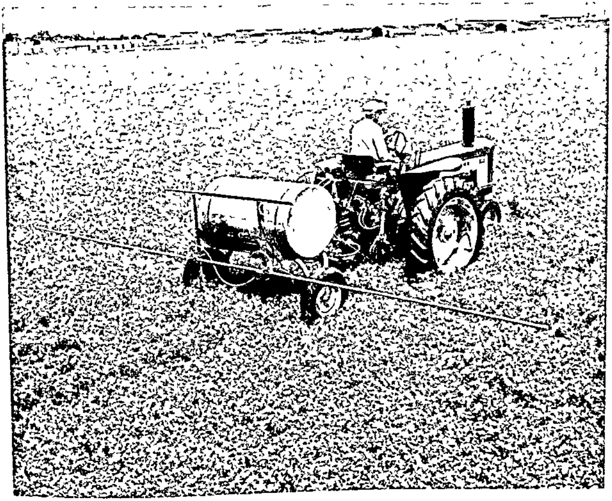


Figure 7-3. Spraying equipment is a good means of pest insurance. (Courtesy Deere & Co.)

being produced to meet this problem. Before release to the public, all pesti cides are tested thoroughly for effectiveness as well as for the safety of the operator and of beneficial wild life. When chemicals are employed to combat insect pests, close observation is necessary in order to locate the pests quickly enough for effective extermination.

It is interesting to note that grass will grow rapidly around manure droppings but cattle will not feed upon such grass. Hence any system of pasturing should include provisions for scattering droppings each time the sward is fertilized and/or mowed.

Importance of Rate of Stocking

Recent work in New Zealand and the United States indicates that the main factor for determining the milk output on the basis of animals or of acres is the rate of stocking. *This possibly is because the entire problem involves three biological systems: the animals, the individual pasture plants, and the herbage mixture.* Each of these systems has the ability to compensate for productive

pressures whether these arise from chopping continuous grazing or rotational grazing For example if the feed supply is short the animals graze for longer periods When the supply is plentiful grazing is selective—the best forage being consumed first When less total feed is consumed the cow probably digests and metabolizes a greater percentage of her nutrient intake

When strip grazing at daily intervals was compared to rotational grazing the main difference was in the behavior of the cows Since strip grazing makes new areas available frequently the cows remain more content than when new plots become available less often as in rotational grazing When cows are rotated onto a fresh area there ordinarily is considerable initial excitement and a tendency to overeat In spite of the excitement milk yields usually increase However as grazing progresses the animals often become discontented consume less nutritious feed by necessity and naturally production drops Yet at *constant* stocking rates the average yield of milk per day and the average daily forage intake were not affected significantly (see Table 7 6)

Table 7 6 Milk Yield (lb/cow/day) on Each Day of Grazing on One Paddock and on the First Three Days Grazing on the Next Paddock (average of 14 occasions)

Treatment	Days									
	On One Paddock						On Next Paddock			Average
	1	2	3	4	5	6	7	8	9	
Low folded	37.5	37.6	37 9	37 7	37.3	36 6	37 0	36 9	36 4	37 2
Low rotational	38.4	39 1	39.5	37 4	35 5	34 2	37 8	38 1	38 0	37 6
High folded	36 0	35 9	35 8	35 9	35 4	34 9	35 1	34 8	34 8	35 4
High-rotational	37 1	37 9	38.5	36 8	35 1	32 6	36 1	36 9	36 8	36 4

Tables 7 7 and 7 8 show that the yield per cow was lower but the yield per acre was higher with a heavy stocking rate[3] These results are easy to explain When the stocking rate is limited the cows select only the choicest forage and hence milk production is likely to be upheld Therefore the less desirable portions are wasted unless some other system is employed to utilize them On the other hand heavy stocking rates force the cows to consume more of the herbage However since the feed selected tends to become progressively less nutritious the yield per acre is enhanced at the expense of yield per cow The data in Table 7 8 show that at the higher rate of stocking the pasture yielded 10 per cent more utilized herbage but that the consumption of dry matter was less by 3 pounds per head daily

As long as stocking rates are based upon accurate observations of the

Table 7-7. Milk Production from the Four Grazing Treatments

Stocking Rate:		Low		High	
Grazing Treatment		Folded Daily	Rotational	Folded Daily	Rotational
Milk yield as lb/cow/day	1957	41.8	41.7	38.4	39.5
	1958	32.8	33.5	30.9	32.2
	1959	35.4	35.3	34.6	34.8
	Average	36.7	36.8	34.6	34.8
Milk yield as gal/acre/year	1957	974	881	977	1007
	1958	939	946	1096	1110
	1959	351	346	418	425
	Average	721	724	830	847

ability of the cattle and availability of the forage, any acceptable method of pasture usage should be satisfactory Naturally, productive forage and cows of high potential are necessary just as with any other system of feeding, if maximum efficiency is to be obtained *However, there must be a compromise between low stocking rates which lead to the highest daily production per cow and the higher rates which give the maximum yield per acre*

When forage is available in amounts too large to be used effectively, it should be clipped carefully and preserved before the quality declines due

Table 7-8. Utilized and Residual Herbage Dry Matter (in 100 lb) and Dry-Matter Intake in lb per cow per day

Stocking Rate:		Low		High	
Grazing Treatment		Folded Daily	Rotational	Folded Daily	Rotational
Utilized herbage as DM/acre/year	1957	60.9	61.1	62.2	66.6
	1958	61.4	70.7	74.4	65.6
	1959	29.0	28.7	29.8	32.6
	Average	50.4	53.5	55.5	54.9
Residual herbage as average DM/acre remaining after each grazing	1957	12.6	12.0	9.9	8.0
	1958	15.0	15.7	13.0	11.6
	1959	7.6	8.1	6.7	6.4
	Average	11.7	11.9	9.9	8.7
DM intake as lb/cow/day	1957	28.9	29.0	24.4	26.1
	1958	23.2	26.7	23.3	20.6
	1959	30.2	29.9	24.6	26.9
	Average	27.4	28.1	24.1	24.5

pressures, whether these arise from chopping, continuous grazing, or rotational grazing For example if the feed supply is short, the animals graze for longer periods When the supply is plentiful, grazing is selective—the best forage being consumed first When less total feed is consumed, the cow probably digests and metabolizes a greater percentage of her nutrient intake

When strip grazing at daily intervals was compared to rotational grazing, the main difference was in the behavior of the cows Since strip grazing makes new areas available frequently, the cows remain more content than when new plots become available less often as in rotational grazing When cows are rotated onto a fresh area, there ordinarily is considerable initial excitement and a tendency to overeat In spite of the excitement milk yields usually increase However as grazing progresses, the animals often become discontented, consume less nutritious feed by necessity, and naturally production drops Yet at *constant* stocking rates, the average yield of milk per day and the average daily forage intake were not affected significantly (see Table 7-6)

Table 7-6 Milk Yield (lb/cow/day) on Each Day of Grazing on One Paddock, and on the First Three Days' Grazing on the Next Paddock (average of 14 occasions)

Treatment	Days									
	On One Paddock						On Next Paddock			Average
	1	2	3	4	5	6	7	8	9	
Low folded	37.5	37.6	37.9	37.7	37.3	36.6	37.0	36.9	36 4	37.2
Low rotational	38.4	39.1	39.5	37.4	35.5	34.2	37.8	38.1	38.0	37.6
High folded	36 0	35.9	35.8	35.9	35 4	34.9	35.1	34 8	34.8	35.4
High rotational	37.1	37.9	38 5	36 8	35.1	32.6	36 1	36.9	36 8	36 4

Tables 7-7 and 7-8 show that the yield per cow was lower but the yield per acre was higher with a heavy stocking rate [3] These results are easy to explain When the stocking rate is limited, the cows select only the choicest forage and hence milk production is likely to be upheld Therefore, the less desirable portions are wasted unless some other system is employed to utilize them On the other hand, heavy stocking rates force the cows to consume more of the herbage However, since the feed selected tends to become progressively less nutritious, the yield per acre is enhanced at the expense of yield per cow The data in Table 7-8 show that at the higher rate of stocking the pasture yielded 10 per cent more utilized herbage, but that the consumption of dry matter was less by 3 pounds per head daily

As long as stocking rates are based upon accurate observations of the

Table 7-7. Milk Production from the Four Grazing Treatments

Stocking Rate:		Low		High	
Grazing Treatment		Folded Daily	Rotational	Folded Daily	Rotational
Milk yield as lb/cow/day	1957	41.8	41.7	38.4	39.5
	1958	32.8	33.5	30.9	32.2
	1959	35.4	35.3	34.6	34.8
	Average	36.7	36.8	34.6	34.8
Milk yield as gal/acre/year	1957	974	881	977	1007
	1958	939	946	1096	1110
	1959	351	346	418	425
	Average	721	724	830	847

ability of the cattle and availability of the forage, any acceptable method of pasture usage should be satisfactory Naturally, productive forage and cows of high potential are necessary just as with any other system of feeding, if maximum efficiency is to be obtained *However, there must be a compromise between low stocking rates which lead to the highest daily production per cow and the higher rates which give the maximum yield per acre*

When forage is available in amounts too large to be used effectively, it should be clipped carefully and preserved before the quality declines due

Table 7-8. Utilized and Residual Herbage Dry Matter (in 100 lb) and Dry-Matter Intake in lb per cow per day

Stocking Rate:		Low		High	
Grazing Treatment		Folded Daily	Rotational	Folded Daily	Rotational
Utilized herbage as DM/acre/year	1957	60.9	61.1	62.2	66.6
	1958	61.4	70.7	74.4	65.6
	1959	29.0	28.7	29.8	32.6
	Average	50.4	53.5	55.5	54.9
Residual herbage as average DM/acre remaining after each grazing	1957	12.6	12.0	9.9	8.0
	1958	15.0	15.7	13.0	11.6
	1959	7.6	8.1	6.7	6.4
	Average	11.7	11.9	9.9	8.7
DM intake as lb/cow/day	1957	28.9	29.0	24.4	26.1
	1958	23.2	26.7	23.3	20.6
	1959	30.2	29.9	24.6	26.9
	Average	27.4	28.1	24.1	24.5

to aging One must keep in mind the effects of pasture management on the future productiveness of both the land and the animals

Value of The Electric Fence

The electric fence has considerable usefulness in pasture management The portable electric fence should be in a zigzag pattern if it is to be moved often This allows the posts to be spaced differently in different parts of the pasture thereby taking up the slack in the wire as the grazing area is brought closer to the fence controller Thus it never is necessary to vary the length of the charged wire There is another advantage to the zigzag pattern—one person can move the fence easily without taking it down To change the fence to a new area it is necessary to move only the alternate posts If that doesn t bring the fence far enough the manager just goes back and moves the remaining posts

Careful pasture management is important when moving the portable electric fence since grazing animals should be confined only to areas where relatively immature forage is available Within reason the more often the fence is moved the easier it is to control the type of forage used However it is seldom desirable to move the fence more than once daily and usually every three to seven days is sufficient At times it will be desirable before the entire field has been grazed to move the fence back to the area which was used first Then the mature forage should be cut for hay or silage

Most trouble from short circuiting in electric fences can be eliminated by using glazed porcelain insulators of the one piece type Grooved insulators are preferable to smooth ones because the grooved insulators not only offer more surface than the others but also the grooves help keep a film of moisture from covering the surface Mowing the fence rows occasionally is another measure that should be used to prevent short circuiting Although some modern electric fences will burn off many of the weeds that contact them the use of voltage high enough for this is questionable Moreover lush growth during rainy weather may result in more weeds than can be handled in this way and these extra weeds will ground the fence

A new development employing a transistorized controller which will exert a voltage field across soil surfaces is under development It will be impossible to ground a fence to which it is attached and it can be used underground or above ground with any type of posts without insulators Electric fencing techniques will be considerably simpler after it becomes available

Electric fences can be dangerous but the use of proper equipment and the observance of a few precautions will minimize the hazards Bare charged wires should never be exposed where they are likely to be contacted

by personnel The fence should be turned off while it is being moved, or when the area is to be mowed or fertilized Only fences which are approved by the Fire Insurance Underwriters Laboratory should be used Interrupted charging at intervals of about one-tenth second, by approved controllers, prevents injuries caused by "freezing" to the fence

It often has been suggested that dry weather makes electric fences less effective and wet weather makes them dangerous Both are possible The electric fence is an open circuit, the charged wire forming one side of the circuit and the ground the other An animal standing on the ground and touching the wire serves as a switch to close the circuit Thus, when the ground is dry the contact may not be satisfactory unless the fence is especially well grounded Most approved fence controllers have a special high-voltage connection to be used only during dry weather This could be dangerous unless care is taken to change to the lower-voltage connection during and after each rain

Training animals for electrical control is desirable Most animals become somewhat excited when they are moved to a different pasture, and unless they have been trained they may go right through an electric fence Confining animals to a corral and allowing them to contact a charged wire once or twice usually is sufficient training It also is a good idea to mark the fence with pieces of cloth or paper when animals are moved to a new pasture The small wire is difficult to see

Power failure usually causes no serious problem The animals have no way of knowing when the current is off After livestock have been trained, many herdsmen don't bother to turn the fence on at all In fact, even after an electric fence has been taken down livestock have been known to refuse to cross the area where it *was* When there's reason to be sure that the fence remains charged at all times, both a battery and an A C controller can be connected with a normally closed relay as shown in Figure 7-4 Thus the A C keeps the battery controller turned off If the A C goes off, the battery controller automatically starts, then turns off when A C service is resumed

For portable fences, lightweight smooth wire is used For semipermanent fences, barbed wire is preferable because it is strong and the barbs can penetrate heavy haircoats, assuring a good contact However, care must be taken not to leave pieces of wire in the fields, as this could result in hardware disease in cattle or damage to implements

One wire strung about 30 inches from the ground is sufficient for cattle and horses One wire is enough for hogs too, but in this case it is strung about a foot above the ground Most sheep operations use two wires at heights of 15 and 30 inches

For semipermanent installations, regular fence posts can be employed

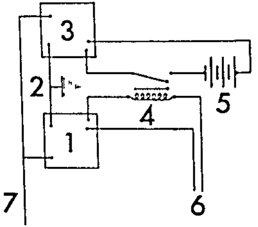


Figure 7-4. A system for automatic operation of emergency battery-operated fencing equipment in event of failure of the A.C. source· (1) A.C. fence controller, (2) ground, (3) battery-operated fence controller, (4) normally closed relay, (5) battery, (6) A.C. source, (7) electric fence.

without trouble at intervals up to 100 feet Movable posts should be spaced at distances varying from 15 to 25 feet

Many electric fencing operations have been abandoned because excessive time and expense were required to keep the systems operating Almost all of this could have been avoided, however by using good materials to begin with Inadequate insulators second-hand wire, allowing weeds to accumulate, and the tendency to use home-made devices account for most malfunctions

An approved electric fence will last for years if it is kept dry and protected with a lightning arrestor placed between the fence and the ground Although the lightweight wire used for portable fences is easily broken, it is inexpensive and can be replaced quickly Good insulators last indefinitely unless they are damaged and batteries remain functional for about three months

It is easy to see why the electric fence has aroused so much interest, and there is no reason why its popularity should not continue There are problems of course, but no particularly serious ones Most livestock farmers should consider using the electric fence because it is economical, effective in many different ways, and when installed and maintained properly, it is safe

8 SILAGE

Silage, or ensilage, is greenchop which has been cut, compressed and preserved by fermentation of itself or an additive, or by applied acids in an air-tight chamber known as a silo The plants alone or with additives should have sufficient sugar and other nutrients to achieve two basic objectives (1) The sugar level should be right to insure good fermentation in silage which is made by this process (2) The silage ultimately achieved by the ensiling process should contain adequate nutrients in terms of cattle requirements and cost Nutrient requirements of cattle and feed composition are shown in Appendix D There are also simple methods for determining dry matter and moisture content, which will be discussed in this chapter

Making and handling silage involves basically three major steps (1) preparing the material for the silo, including cutting of the crop and any pretreatments that may be used to improve the ensiling process, (2) storing the forage in the silo where the ensiling process takes place, and (3) removing the silage from the silo at the time of feeding

Pasture crops, sorghum, corn, and other grains may be used as the basic feedstuff from which the silage is to be prepared If a hay crop is used, it is cut before it has formed seeds, and is carried to the silo The means of conveying the greenchop will vary depending on the size and type of the silo and the equipment available The choice of basic material will depend upon such questions as availability, nutrient requirements, and equipment available (Figure 8-1)

Equipment plays an important role in filling the silo (Figure 8-2) However, the equipment needed will vary according to the silo structure as well as other relevant considerations, so that we find tower silos will require blowers or elevators whereas in other types dump trucks or self-unloading wagons may be used Nevertheless, the range and flexibility of equipment available is quite impressive

Since the structure in which silage is made must be almost air-tight, sealing of the silo is necessary The types of materials used in sealing vary, but plastic film is the most popular It is interesting to note that except in the case of the gas-tight silo sealing involves an extra operation

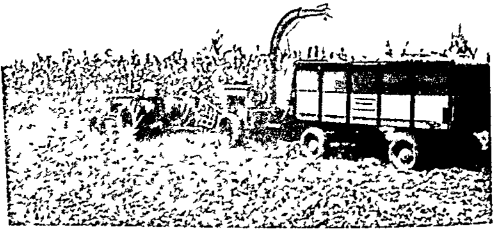


Figure 8-1. Corn is one of the best crops for greenchop or silage.

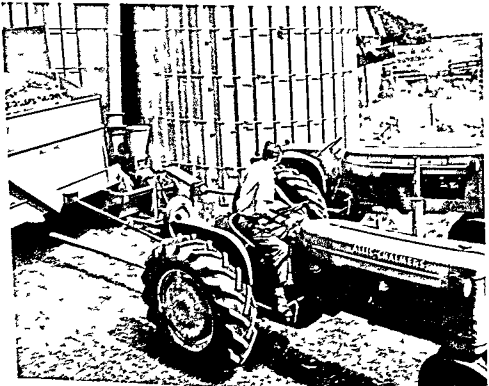


Figure 8-2 One man can fill upright silos with modern equipment (Courtesy Allis-Chalmers Manufacturing Co)

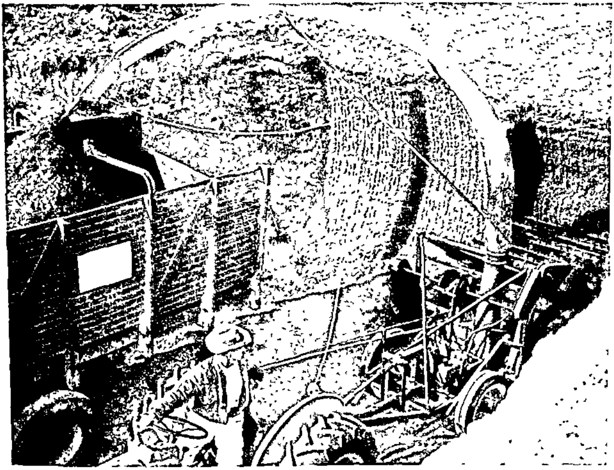


Figure 8-3. Tractor-mounted, tractor-powered equipment for unloading horizontal silos. (Courtesy Sunflower Industries, Inc.)

Adequate sealing is essential to the success of the ensiling process. However, other techniques are also important, and various conditioners are frequently employed in the making of silage. The silage that is stored and preserved is removed when the time comes for feeding, and the types of equipment used for removal vary considerably, depending upon the type of silo involved (Figures 8-3, 8-4, 8-5).

Silage production in the United States has increased tremendously since World War II, and it still is increasing rapidly. This is the result of the following factors:

(1) *Newer research into methods and materials for high-quality silage* production and storage.
(2) Emphasis on grassland farming, much of which has occurred in areas where natural conditions are unfavorable for hay curing.
(3) The need for better livestock feeds, as a result of the general economic trend. Margins of profit have narrowed somewhat in most areas This has caused emphasis on the use of high-quality roughage.
(4) High-producing crops such as corn can be stored most effectively as silage.

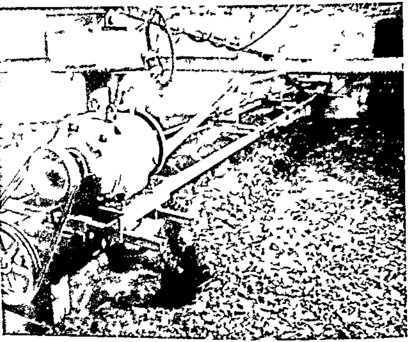
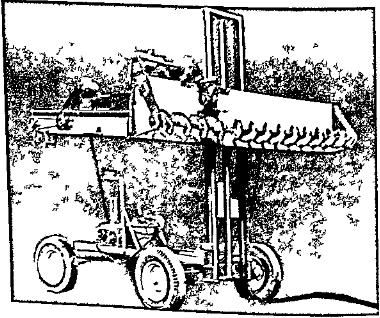


Figure 8-4 Automatic equipment unloads jumbo silos down the torpedo hole (Courtesy James Manufacturing Co)

Figure 8-5 An electrically driven unloader for horizontal silos, developed by engineers of the USDA (Courtesy U S Department of Agriculture)



of ensiling this can be measured as accumulated acidity When the pH has reached 3 or 4 most metabolic processes stop (pH is the symbol used to express acidity) It is the logarithm of the reciprocal of the hydrogen ion concentration

$$pH = \log 1/(H^+)$$

Thus in the case of pure water which is neutral the concentration of hydrogen ion is 1×10^{-7} moles per liter $pH = \log 1/10^{-7} = \log 10^7 = 7$ Values below 7 indicate the degree of acidity whereas those above 7 show the alkalinity

In practical management some compromise may be necessary The faster the crop can be handled the sooner losses resulting from continuing metabolism and oxidation can be stopped Hence the availability of machinery and labor are important considerations

Wilting High moisture forages require more preservatives than do those which are higher in dry matter Although dry matter content can be increased by wilting this requires additional labor On the other hand with wilted plants less labor equipment and silo space are allocated to handling water In any case the relative availability of extra help or extra preservatives must be considered

Although partial field drying allows repiration and enzyme action to waste nutrients it has been shown that photosynthesis can continue and thus some nutrients are *formed* while forage is drying Of decided advantage is the fact that the greater osmotic pressure of the wilted forage in the silo may be particularly unfavorable for the growth of putrefactive organisms It has been postulated that wilting increases the content of fermentable sugars in forage but this appears to be true only under certain conditions Obviously any given silo space will hold more dry matter in the form of partially dried forage than when the same material is ensiled in the fresh state The practice of partially field drying forage for silage is not new in Italy it has been practiced for more than 40 years

Following extensive research Samarani[8] developed a system for ensiling forage containing approximately 40 to 50 per cent of moisture Pressure was applied to the ensilage and thus rather elaborate equipment and considerable labor was necessary In the United States most forage for ensilage if wilted at all is put into silos when the moisture content is 60 to 70 per cent Use of gas tight silos reduces somewhat the labor and equipment requirements for making wilted silage and permits the use of ensiling materials as dry as those employed in the Samarani process Hence interest in low moisture silage has increased and a new word haylage has been coined to describe it An extra operation still is necessary however since the greenchop must be cut with one machine operation and

picked up by another machine—an additional time-consuming process. This is compensated for to a certain extent by the fact that considerably more dry matter can be handled in each load.

Soil texture also must be considered in deciding whether to use directly cut or partially dried forage. Sandy soils are likely to be picked up by the machinery when field-wilting is practiced. As much as 50 per cent of the dry matter in experimental silage so processed was found to be sand in one experiment at the Florida station.

Effect of Crimping or Crushing Forage. Machines designed to crush or crimp stems to make plants dry quickly for hay also are valuable in preparing forage for the silo. As fresh forage is run through the machines and crushed, many of the cells are broken open The contents of the cells thus are spilled onto the plants These cellular materials are high in soluble carbohydrates, which become available to the fermentive bacteria.

About 10 per cent more dry matter can be preserved in finely cut and bruised forage than from coarsely cut plants. Bruised-forage silage also is more acidic and contains a larger percentage of the desirable types of acids than plain-forage silage

Estimating Moisture Content. The approximate moisture content of greenchop can be estimated with reasonable accuracy by means of the "grab test," in which a ball of forage is compressed tightly in the hand and then released suddenly Only forage which is cut very short is suitable for this test. The condition of the ball after testing indicates the approximate moisture content as follows. (1) If the ball holds its shape and considerable free juice is evident, the moisture content is considered to be 75 per cent or higher; (2) if the ball holds its shape but little free juice is observed, the moisture content is likely to be 65 to 75 per cent, (3) if the ball disintegrates very slowly and no free juice is evident, the water content is in the nature of 60 to 70 per cent, (4) if the ball falls apart and little or no free moisture is observed, the water constitutes less than 60 per cent of the forage. In most cases the moisture content indicated by the falling apart of the ball represents minimum dryness, since drier material is difficult to pack. In gas-tight silos where packing is no problem, forage as low as 40 per cent in moisture is satisfactory If the moisture content is above 70 per cent it is well to use an absorptive preservative to prevent excessive run-off and to help establish osmotic pressures favorable to lactic-acid organisms.

A large number of systems are available for accurate moisture determination, but most of them are either time-consuming or expensive. One inexpensive test which can be run quickly enough for the results to be used before forage is ensiled is the oil-distillation method [1] The equipment consists of (1) an accurate scale or balance with a capacity of 500 to 1000

grams, (2) a thermometer which reads to 200°C, (3) a one-quart metal container with lid, screen, and wire handle The container and screen resemble ordinary French-frying utensils, and the forage, in effect, is French-fried The only other equipment needed is (4) cooking oil and (5) a hotplate The container, oil, and forage are weighed together The forage weight is determined independently also The oil with forage immersed then is heated to 145°C (293°F), a temperature at which the forage loses its moisture Then by reweighing the container with the oil and forage residue still in it, the moisture content is determined as the loss in weight If 100 grams of forage are used, the loss in weight in grams equals the per cent moisture of the forage Of course, care must be taken that the forage sample is representative of the field from which it is obtained

Additives or Conditioners

Although wilting and/or breaking the plant cells offers many advantages for ensiling forage, the trend at present is to keep the operation simple Thus forage is cut and loaded into wagons in one operation The only other main operation is to unload automatically into the silo Many forages handled in this way must be ensiled with preservatives Additives often are called "conditioners" or "stimulants," and there are many of them As mentioned previously, corn silage is a roughage and a concentrate, and as such, it has a self-contained conditioner (the corn kernels and sugars)

Plants such as sorghum or corn contain large amounts of fermentable sugar which also serves as a built-in silage conditioner In fact, such a large part of sugar cane is bacterial food that excessive fermentation, causing a very large loss of nutrients may occur—perhaps making the value of some varieties of the plant doubtful as material for silage

For most unwilted legumes additives seem essential to prevent putrefaction, and they can be incorporated easily (Figure 8 6) There are one or possibly more exceptions to this general postulation As previously indicated, sweet lupine ensiled with no additive and no wilting has been preserved well at the Florida station The process was efficient and the product had no putrefactive odor whatever

There are many substances now in use as silage conditioners These accomplish their purpose in various ways (1) by simply reducing the pH, (2) by chemical inhibition of enzymatic fermentation and respiration activity, (3) by inhibition of putrefactive bacteria, (4) by supplying soluble sugars for lactic acid bacteria (5) by adjusting osmotic pressure of the silo contents and (6) by absorption of juices which contain soluble nutrients

Mineral Acids For 30 years sulfuric and hydrochloric acids have been used in Finland to preserve forage This method, developed by Artturi I

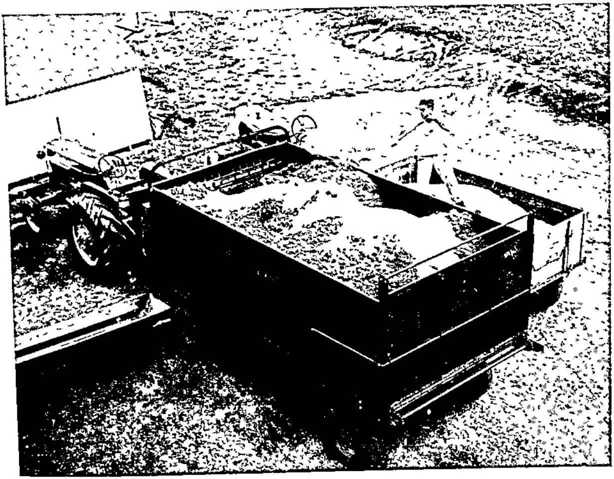


Figure 8-6. Preservatives spread over the load are mixed into silage during unloading. (Courtesy New Idea Farm Equipment Co.)

Virtanen in 1929, is known by his initials—the A.I.V. method. A.I.V. silage is made by spraying 0.1 normal acid on the forage, the amount of acid per ton of forage being about 6 liters. This causes the pH to be lowered to a value of very slightly less than 4. All the acid is used up in the process. Organic acids, including fumaric, citric, malic, and oxalic, are displaced by the mineral acids. The organic acids then form salts, and the mineral acids are neutralized. Thus the pH is low enough to stop respiration, enzymatic action, and most bacterial action. Lactic acid bacteria continue working above pH 3 but their activity usually is not considered to be harmful.

Phosphoric acid has been used to a limited extent in the same way. It has never been popular, however, because it often causes indigestion unless the excess acid is neutralized. Yet many soils and the forage raised on them are deficient in phosphorous. This deficiency can be overcome by the phosphorous of the acid and if calcium carbonate is used as the neutralizer the calcium-phosphorous ratio is quite favorable. A 75 per cent solution of phosphoric acid sprayed onto silage at the rate of 1 gallon per ton of fresh

forage preserves the nutrients well Perhaps this preservative deserves further critical investigation

Sulfur Dioxide Sulfur dioxide gas applied from cylinders was found to be an effective preservative Sodium metabisulfite however has replaced the gas per se because of its greater convenience When 8 pounds per ton of sodium metabisulfite are added to each ton of fresh forage sulfur dioxide gas is liberated This gas combines with moisture and forms sulfurous acid which effectively inhibits biological processes in the forage in the same way that phosphoric acid and the A I V mixtures do This is a very effective preservative inexpensive and easy to use Sulfur dioxide gas however is quite harmful to humans for sulfurous acid can be formed on the skin or within air passages and lungs causing serious trouble Thus care must be taken to avoid the fumes The SO_2 fumes also are quite corrosive to metals Therefore when this preservative is used it is best to make application directly onto the forage *after* it is in the silo as self unloading wagons or silage blowers have been seriously damaged by contact Another problem is evident in using sodium metabisulfite in horizontal silos which are to be packed with tractors These machines also can be damaged by SO_2 fumes

Antibiotics Antibiotics which affect putrefactive bacteria appear to offer promise as silage preservatives Zinc bacitracin used in this way produced silage which compared favorably with similar forages ensiled with molasses[7] In other work[2] aureomycin albamycin neomycin streptomycin terramycin oleandomycin and erythromycin also have proved very effective in preserving pearlmillet Apparently the antibiotics inhibit both fermentative and putrefactive organisms When a good seal is accomplished however the lactic acid organisms (being anaerobic) survive and eventually overcome the very low level of antibiotics (5 grams per ton) But since the proteolytic organisms found in silos are *aerobic* they never recover in those which are properly sealed

Molasses Blackstrap citrus corn cane wood beet or other molasses products are effective preservatives For grasses 40 pounds per ton are used whereas 80 pounds are preferable for legumes

Bulky Concentrates Beet pulp citrus pulp corn meal ground snapped corn and other absorptive high energy concentrate feeds are effective silage preservatives when added at a rate of 150 pounds per ton This is less expensive than it appears since only about 10 per cent of such preservatives are used in fermentative processes The remainder is merely stored with the silage In many operations this feature is an added convenience and considerable amounts of bulky concentrates are stored in silos where they preserve forages and absorb soluble nutrient containing juices which otherwise would be lost in run off The bulky concentrates are available as feed when the silage is used Moreover at the Florida

station the juices were so high in dry matter that citrus pulp contained more nutrients when removed from experimental silos than when placed in them with the green herbage, despite ensiling losses by fermentation

Other Conditioners. Certain other conditioners are effective Dry whey products added at the rate of 80 to 100 pounds per ton are effective preservatives Various salts, including formates, nitrates, and chlorides, have been investigated as silage conditioners, but generally results with these substances have not been satisfactory Addition of calcium appears to make the fermentation proceed for longer periods, and this appears to be beneficial particularly for silages made from grain crops

Silo Losses

Some losses are expected in all silo operations, but careful management can keep them at a minimum Those due to heating, molding, and rotting occur as a result of aerobic activity caused by air pockets, leaks in the silo walls, or inadequate sealing They vary from almost zero in well-packed, properly sealed silos, to 20 per cent or more in loosely filled, inadequately sealed horizontal silos There is particular danger of such losses in forage which is somewhat dry because it is difficult to pack

Fermentation. Fermentation losses due to normal microbial and physiological activities of the aerobic organisms range from 3 to 8 per cent This varies with the ensiling period, moisture content of the herbage, the amount of surface exposed, and the packing efficiency High-moisture forages usually undergo more fermentation than wilted herbage Fermentation losses usually are higher in trenches and stacks than in upright silos because of more surface exposure, less packing, and more difficult sealing problems Experimental results from various locations differ as to the economic significance of losses from the breakdown of protein by aerobic bacteria Cattle often will consume foul-smelling silage and utilize the nutrients of it well No one doubts, however, that silage without putrefactive odors is more desirable from the point of view of the workers

Seepage. Seepage losses vary with the moisture content of the herbage and the absorptive capacity of the additive The solids content of silo seepage varies from 4 5 to 11 5 per cent In most silos seepage occurs from any forage containing 70 per cent or more moisture It is more pronounced in tower silos because of the weight of the silage in relation to the surface Perhaps this is one reason why horizontal silos are popular in regions where high-moisture herbage constitutes the bulk of silage crops

THE SILO AND ITS REQUIREMENTS

A very large number of different silo types are in use These vary from massive concrete structures with complete equipment for compressing the contents, to simple plastic bags Other types include conventional and

gas tight tower silos, tub silos, trench pit, and clamp silos, wire and plastic silos, and bunker silos which may be made from various materials, but which usually are of wood or concrete

Venting the Silo

All silos are designed to provide anaerobic conditions, yet completely airtight storage is not only difficult to accomplish, but inadvisable When a container is sealed completely, the gas inside expands and contracts as the temperature rises and falls Some of the time there will be a vacuum, perhaps enough to buckle the walls Hence some ventilation is essential to relieve vacuums or excessive pressures in the storage Venting also is necessary to allow air to enter the structure to replace feed which may be removed Small amounts of air introduced occasionally at the top of the storage and allowed to mix with the accumulated gases before contacting the contents, are not harmful These principles apply to all silage operations, but are especially important in the case of gas-tight silos and structures for storage of high moisture grain

Tower Silos

Conventional tower silos still are used widely where silage is not wilted to an extent that reduces the moisture below 60 per cent Where the moisture is reduced to about 40 per cent the forage must be weighted unless a near perfect seal can be achieved Weighting is done routinely in Italy, but in America where labor is very expensive this part of the process is eliminated, and thus higher-moisture material must be used Ordinarily concrete, steel, and other upright silos are prefabricated in the form of staves which are assembled at the site of erection A typical stave silo is shown in Figure 8-7

Most tower silos are 16 to 20 feet in diameter and about 30 feet in height Fresh forage is blown in at the top and when ready for use the silage is removed through a series of openings at one side The openings are sealed as the silo is filled and the sealing is removed as necessary for unloading

Unloading In cold climates silage is likely to freeze and hence machines often are used to unload upright silos These machines have not been popular in warm climates since the silage there does not freeze Usually machinery unloads unfrozen silage from tower silos at about the same rate that it can be removed by hand

The difficult part of unloading conventional tower silos is in getting the feed across the 16 to 20 feet to the opening This difficulty can be overcome by using a short electrically operated conveyor As the ensilage drops from the silo it should fall directly into the wagon or truck or bet-

the silo contents Within the volume limitations of the bag the pressure within the structure is maintained essentially at zero A pressure-vacuum relief valve which employs the same principle as a safety valve on a steam boiler when necessary handles volumes larger than the bag

Forage is put into gas-tight silos through an opening which is just large enough to accommodate a pipe from the blower The opening is sealed with a screw cap when not in use The ensilage is removed from the bottom by machinery Since sealing is almost perfect, no packing is necessary, and forage or grains of almost any moisture content can be used Feeds varying from almost dry forage (haylage) to high-moisture grains can be stored in this way with virtually no loss

Tub Silos

Tub silos are upright silos of very wide diameter As some of these large-diameter silos are being filled, a heavy cylinder (torpedo), originally fixed upright on the bottom, is pulled slowly up through the center Since the forage is heavy, it settles quickly around the torpedo, leaving a hole in the middle when the operation is completed The forage is unloaded through this torpedo hole by hand or machinery, and after unloading, it is handled in the same way as feed from other tower silos An innovation is a structure of concrete or metal with four or more series of doors These tub silos are fairly easy to unload by hand because most of the contents are near a door

Pit Silos

Pit silos are just what the name implies They are used widely in many European countries but seldom are seen elsewhere, for the reason that when they are large enough to hold a practical volume of silage, the labor required for their operation usually is greater than for other types of structures Also, in many parts of the world, there is danger that the water table will rise high enough to enter the bottom of the pit

Trench Silos

As the name implies a trench silo is not as deep as a pit silo, and is horizontal Here there is more chance for exposure of the contents to the air, and thus more spoilage can be expected On the other hand, the trench is so much more readily accessible, that labor costs and requirements are very low compared to those involved in the use of deep pits for storing herbage Thus where operations are large and the soil is suitable, the trench continues to be popular

A low water table and clay soil are desirable in the location of trench silos Often the trench can be dug into the side of a hill so that it is easily

accessible for loading It is a good idea to slope the trench lengthwise from the uphill end so that a wagon or truck can enter there and leave at the downhill end In this way the vehicles which bring the silage from the field also help to pack it

The sides of trench silos should be sloped outward from bottom to top to help keep the contents tightly packed and to prevent cave ins However if the sides slope too much settling is likely to be hindered It seldom is desirable to slope the sides more than 3 inches per foot If cave ins occur with less than this much slope it is advisable to line the silo with concrete

The Bunker Silo

For areas in which trench silos require lining because of soil types or where water tables are high perhaps the bunker silo (Figure 8 8) is more practical Bunker silos are above ground structures composed of walls be tween which ensilage is compressed The walls may be of lumber poured concrete concrete blocks or any other desirable material In any event they must be strong and should be braced since the weight of the silage will exert considerable pressure

Forage is put into and taken out of bunker and trench silos in much the same way Dump trucks or self unloading wagons can be driven through dumping their load on the way Forage then is spread and packed by wheel tractors equipped with blades Wheel tractors are best for packing

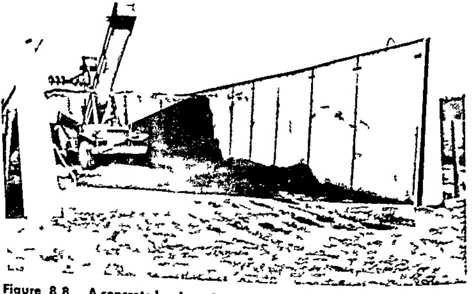


Figure 8 8 A concrete bunker silo with sloping sides

since the weight of the tractor is concentrated in the area occupied by the wheels, and thus considerable pressure can be applied A blade, which may be at either the front or back of the tractor, is used to smooth and spread the herbage

When forage is packed into bunker silos to a height of over 5 feet, it is difficult to enter with a vehicle Hence, use of self-unloading wagons or dump trucks becomes difficult This problem can be solved by building a long sloping ramp at one end The end of the silo at which the ramp is located is filled first using an elevator or blower Then vehicles can be driven up the ramp, onto the silage, and out the other end of the silo, unloading on the way Thus it is not necessary for trucks or tractors to climb a pile of silage Other alternatives are use of blowers and elevators to fill the entire silo, or keeping an extra tractor in the silo to help pull loaded vehicles onto the pile of herbage

Clamp Silos

Where soil is suitable but the water table is close to the surface, clamp silos can be used This is a compromise, being part trench, part bunker, and partly just stacked silage Here a shallow trench is dug and the soil so excavated is piled along the sides to increase the height of the walls Cut forage then is packed as tightly as possible into the trench and as high as it is feasible above the ground Silage stored in this way keeps well, especially if a good plastic seal is installed Clamp silos are used widely in Europe but have not been popular in North America Perhaps this is because materials here are readily available for building bunker silos

Use of Plastic Film

Plastic film employed in various ways is one of the most versatile and useful materials available for forage preservation Silos of various sizes can be fashioned with plastic film and welded wire fencing Woven wire should not be used because projections from it are likely to puncture the plastic A good silo can be made from plastic in the form of a tube held upright by the welded wire (Figure 8-9) To set up this silo, a section of wire is looped into a circle of the same diameter as the plastic tube, and secured with twine The plastic is then tucked under at the bottom and draped over the wire circle Feed bags or other protecting materials can be placed over the edge of the wire to prevent punctures when the plastic is in the draped position When silage has been stacked above the first section, the second can be installed The sections are tied together with twine because wire ties could make holes in the plastic

These tube silos can be built up to a height of 12 feet in the manner described Attempting to go higher usually puts too much pressure on the

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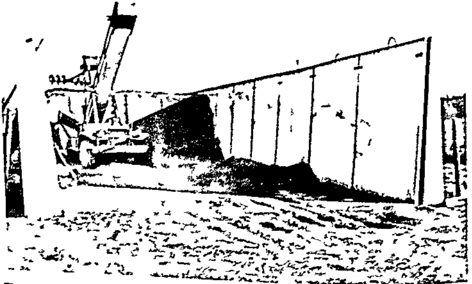

Figure 8-8 A concrete bunker silo with sloping sides

since the weight of the tractor is concentrated in the area occupied by the wheels, and thus considerable pressure can be applied A blade, which may be at either the front or back of the tractor, is used to smooth and spread the herbage

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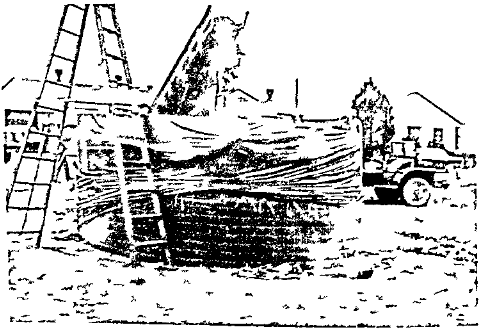

Figure 8 9 A plastic tube silo

bottom Moreover it is just as easy to start another silo at the ground level again

It is very important to locate tube silos on well drained soil The ground must be level since leaning will put too much pressure on the low side causing rupture of both plastic and wire

To remove silage from a plastic tube it is preferable to take the wire off one section at a time and to peel a part of the plastic back each time silage is removed This exposes the feed so that it can be raked off into movable bunks or conveyances The plastic can be kept closed except when unloading is in progress Thus spoilage is kept to a minimum

Silage Bags

Smaller tubes of plastic can be made into individual 100 pound or smaller silos Thus managers of small livestock operations can make silage without expensive structures (Figure 8 10) The ends of each small tube are double tied making a bag with a handle at each end The use of bags fashioned in this way need not be confined to small operations however They are an excellent means of feeding silage to larger herds during the summer—when only small amounts of stored roughage are needed to supplement pastures—thus avoiding exposure of the surface of a full sized silo possibly leading to excessive spoilage

Stack Silage

Sheets of plastic can be used effectively to cover stacks of silage The forage is piled on well-drained soil or on a concrete slab (Figure 8-11), and then covered with plastic film (Figure 8-12), preferably at least 8 mils (008") thick At the ground level the edges may be buried or held with blocks The top should be covered to help hold the plastic down, while soil can be used for this purpose, sawdust or other nonabrasive materials are preferable, since soil is likely to contain pebbles which may puncture the plastic

Silage can be stacked with a farm elevator No packing is necessary when the stacks are covered with plastic They can be of any size, hence, for large herds a one day supply can be put into each stack This is especially important during the summer when spoilage is more likely to occur at the feeding surface

Baled Silage

Stacks of silage also may be made with baled forage The mistake most often found with this type of operation is in making the bales too big Silage

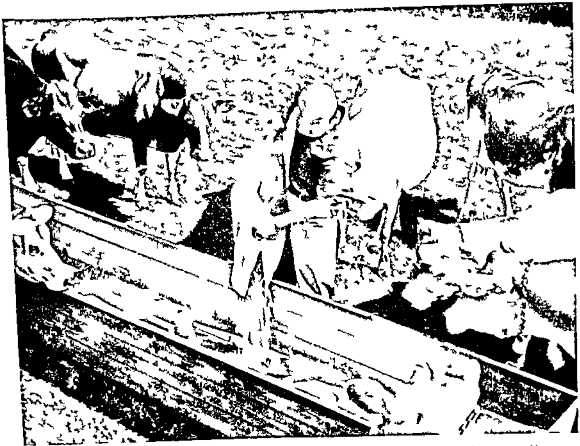

Figure 8-10 Plastic bags are practical silage containers for small operations

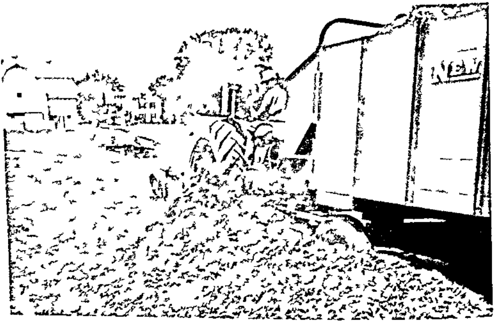

Figure 8-11 Stacking of forage preparatory to sealing with plastic film (Courtesy New Idea Farm Equipment Co)

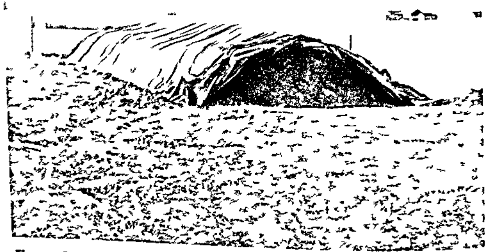

Figure 8 12 Stacked forage can be sealed perfectly with various types of plastic film (Courtesy New Idea Farm Equipment Co)

weighs about 40 pounds to the cubic foot Hence, a 16 inch bale is as large as one man can expect to handle safely These small bales should be piled at random, since this method requires less labor than stacking, and the bales are less likely to shift and tear the seal as moisture is lost and shrinkage occurs

Sealing the Silo

The gas tight silo is sealed by merely screwing the cap into place Plastic sleeves are gathered and tied at the top Bag and plastic covered stacks are sealed in the storing process

For all other silos sealing is a most important extra operation Various materials are used for silo seals Whatever is used should be airtight, impervious to and nonreactive with silage acids, and flexible Impregnated roofing felt meets these requirements, though more flexibility is desirable Building paper is airtight and flexible but some silage acids attack this product

At present, plastic film shows more promise than does any other material for sealing silos Upright silos can be sealed easily by using a short section of plastic tube the same diameter as the silo The tube is placed on top of the silage about 5 feet from the top of the silo, the bottom is tucked under, and the sides are draped over the top If the silo is covered by a roof, it may be necessary to roll the sides of the tube in, rather than draping them over the sides of the silo Then the tube is unrolled as it is filled When the tube is filled, it is gathered and tied Thus no air can get to the silage and often spoilage is nil

It is especially important to get a good seal on horizontal silos, since there is a rather large area of surface to these structures and hence a chance for considerable spoilage Sealing material (preferably plastic) is fastened at each side extending 2 to 3 feet over the top the extra material being folded over the side In wooden silos, the side sheets often extend to the floor In clay or concrete silos it is not necessary for the plastic to extend downward from the top by more than 3 to 5 feet depending on the extent to which settling is expected to occur It is best to tuck the plastic under at the sides so that they will not be exposed by settling of the silage The side sheets should be long enough to lap across the ends Another sheet of plastic can be fastened at the floor lapping upward across the ends After the top sheet is added the ends of the silo are sealed in the same way the end of a package usually is The top cover is allowed to lap over the sides by two feet or more The side sheets and top cover then are rolled together and fastened down at each side Thus the entire silo is made air-tight

Excess gas will diffuse through the plastic though there could be a

noticeable distension during the first day. Air will not diffuse into the silo, however, because if there is a differential in pressure between the inside and outside, the higher pressure is likely to be on the inside.

Even when silos are covered with airtight materials it is a good idea to weight the cover, and in the case of horizontal structures, it is almost necessary. Thus if a puncture should occur, only a small area would be exposed, whereas if the cover were not weighted, it is possible for one small hole to result in air contact and subsequent spoilage of the entire surface.

Capacity of the Silo

It is quite easy to figure the volume in cubic feet of almost any silo. Upright silos are cylinders, and hence the volume is $\pi R^2 \times h$, where $\pi = 3.1416$, R = radius, and h = height. Since horizontal silos usually are made with straight sides, the volume is mere length × width × height. If the sides slope, it is necessary to use an average width which is $\frac{w \text{ top} + w \text{ bottom}}{2}$.

Most data on silo capacities are computed from the densities at various depths of corn silage containing 70 per cent moisture. These do not differ greatly from the densities for grass silage under similar pressure. Since the width, height, and slope of the sides of horizontal silos vary so much, a table for this type of structure is not practical. Silage in horizontal silos will weigh 35 to 40 pounds per cubic foot. If density is 35 pounds per cubic foot, height is 6 feet, width 20 feet at the bottom and 21 feet at the top, and length is 60 feet, capacity may be calculated as follows:

$$\frac{21' + 20}{2} \times 6' \times 60' = 7380 \text{ cu ft} \times 35 = \frac{258{,}300}{2000} \text{ lbs} = 129 \text{ tons}$$

The same formula will work for horizontal silos even after part of the silage has been fed, since that remaining part will differ only in length.

For upright silos there is another complication: as the depth in the silo increases so does the density because of the pressure from above. Use of appropriate tables makes it easy to calculate the amount remaining after settling and partial feeding from tower silos, however. For example, if a 16- by 40 ft. tower silo contained 35 ft of settled silage at the beginning of the season and 20 ft had been removed, the weight of the remainder can be calculated as follows:

Original depth × cu ft/ft (Table 8-1) × av. lbs/cu ft (Table 8-2) minus depth removed × cu ft/ft (Table 8-1) × av. lbs/cu ft (Table 8-2), hence $(35 \times 201 \times 44.3) - (20 \times 201 \times 34.9) = 171{,}352$ lb or 85.68 tons

Table 8-1. Upright Silo Capacities in Tons*

Inside Diameter (ft)	12	14	16	18	20	22	24	26	28	30
Cu ft per ft of Depth	113.1	153.9	201.0	254.5	314.2	380.4	452.4	530.9	615 8	706.9
Depth of Silage (ft)	Capacity (Tons)									
20	36	50	65							
30	68	92	121	151	186	225	268	314		
40	100	135	177	224	276	332	394	463	538	617
50	133	183	238	302	373	452	538	631	732	840
60	172	234	306	387	478	579	689	808	937	1076
70	213	290	379	480	592	716	852	1001	1162	1332

*Hoard's Dairyman, April 10, p. 387 (1960).

Table 8-2 Weight of Settled Silage per Cubic Foot*

Depth of Settled Silage	Average Wt per cu ft	Depth of Settled Silage	Average Wt per cu ft
Feet	Pounds	Feet	Pounds
1	18.5	21	35.6
2	19.7	22	36.3
3	20.8	23	36.9
4	21.8	24	37.6
5	22.8	25	38.2
6	23.8	26	38.9
7	24.7	27	39.5
8	25.6	28	40.2
9	26.4	29	40 8
10	27.3	30	41.4
11	28.1	31	42.0
12	28.9	32	42.7
13	29.8	33	43.2
14	30.6	34	43.7
15	31.3	35**	44.3**
16	32.1	36	44.9
17	32.8	37	45.4
18	33.5	38	45.9
19	34.2	39	46.5
20**	34.9**	40	47.0

*Hoard's Dairyman, April 10, p. 387 (1960).

**Referred to in text.

CORN AND HIGH MOISTURE GRAINS

Grain crops may be ensiled as whole plants or the seeds may be harvested before maturity and ensiled as high moisture grains Corn is the main crop handled in this way but sorghum milo and the small grain crops also can be ensiled either as whole plants or as high moisture grain

Corn Silage

One exception to the rule for using plants before seeds form concerns corn which is cut for silage In this case more nutrients are obtained *after* seeds are formed Corn silage is not just a roughage it is a *concentrate* as well as a roughage The corn grain in silage is high in soluble nutrients and low in fiber Hence the content of energy bearing nutrients in corn silage is high compared to silages made entirely from leaves and stems This must be considered when high energy feeds are supplemented to meet the animal s nutrient requirements

Maturity Generally it is advocated that corn kernels be allowed to reach the dough stage before ensiling The kernels are firm being filled with sugars and starches Earlier when the kernels are soft and filled mainly with fluids (milk stage) resulting silage would be lower in nutrients because maturation of the seeds occurs largely as a result of synthetic processes as long as the leaves are green Later when the grain is hard and flinty the rest of the plant is likely to have deteriorated In dent varieties one can tell when the kernels have reached the best stage for silage because at the proper stage of development the dent is very distinct At this point the chopper will knock about half the kernels from the cob during the cutting process

Maturity of the kernel takes care of the concentrate part of corn silage The roughage part must not be ignored however It is our purpose to ensile corn when the kernel is as mature as possible (thus giving corn silage the characteristics of concentrate feeds) but at the same time most of the leaves must be green since leaf content is characteristic of good roughage

Some compromise naturally is necessary Silage made of very immature plants is likely to be too acid Moreover when the corn is put into the silo when it contains many green leaves and the grain is in the dough stage juice (the amount varying with the type of silo) will run out Nutrients are lost in this way On the other hand when corn dries sufficiently to prevent silo seepage its palatability and nutrient content are generally reduced considerably Therefore the best managers plant silage corn at staggered dates and if one field matures too fast or if the kernel leaf relationship is wrong one has other chances in the later plantings

The oat plant and possibly similar species store more nutrients than are depleted until the milk stage After this the quality of the forage decreases

rapidly. Hence oats yield the most productive nutrients when seed heads have just formed.

Recent emphasis on high-energy feeding has prompted many farmers to leave some of the roughage portion out of grain-crop silage. Thus by cutting the whole plants from one row of corn and picking only the ears from the next, the concentrate-roughage ratio of corn silage is narrowed. Another method involves cutting only the center of the corn plant. The part above the ears and near the base of the stalk are lowest in nutrients, and they are left on the land. For sorghum, oats, milo, and other grains, often the harvester is raised to a point which leaves most of the plant other than seed heads standing.

The Trend Toward Ensiling High Moisture Grains

Grains alone often are ensiled before nutrients are lost due to processes of maturation. High-moisture grains such as corn, oats, wheat, rye, sorghum, and milo are being ensiled in ever increasing quantities. Grains are highest in nutrient content per unit of dry matter before maturing beyond the point at which moisture content is 20 to 30 per cent. With this system there is no drying loss, picker and handling loss, and very little ensiling loss

Estimates of silo capacity from volume determinations are more accurate for shelled corn or similar grains than for forage. A bushel of No. 2 corn is defined as 56 pounds of corn with a moisture content of 15½ per cent, and it occupies 1¼ cubic feet per bushel. In this state corn can be stored safely in air and is not considered high-moisture grain. The capacity of silos or circular grain bins for dry corn is the volume of the structure in cubic feet (given in Table 8-1) divided by 1.25 or multiplied by 0 8.

Wet shelled corn (25 to 30 per cent moisture) occupies more space than dry corn. From weigh-ins on four test silos at the University of Illinois, it was found that for 25 to 30 per cent corn a satisfactory figure for estimating capacity is 1.4 cubic feet per bushel. Hence for wet shelled corn the capacity is the volume of the storage structure in bushels divided by 1.4.

The Stored Grain. After high-moisture grain has been put into the silo, most of the oxygen present in the storage space is converted to carbon dioxide by respiration. This happens within a few hours after the structure has been filled, and then fermentation begins. After weeks of storage, such grain has a fermented odor. The texture is softer than that of dry grain and the color is somewhat darker. It is highly palatable to livestock. Ensiled grain loses its ability to germinate, however, and hence is suitable only for use as a feedstuff.

Loading High-Moisture Grains Getting high-moisture corn or other grain into the air-tight silos poses no special problems, with one exception. If

shelled corn is put in with a blower, the machinery should be run as slowly as possible If the blower is run too fast the kernels will be cracked This cracked corn will not spoil as readily as the whole kernels while it is in the silo but it will spoil more quickly than the whole kernels when put in self feeders Cracked corn is likely to bridge over the type of unloading augers which are used in airtight structures Thus a layer of corn forms above the auger without touching it The corn forming the bridge cannot move and it prevents the grain above it from falling into the auger

The problem of loading ear corn, or shelled corn, into the larger diameter silos with top center opening has been solved by using slow-speed blowers and 22½° elbows in the pipe to produce a slow, gentle curve for the material as it is blown into the silo Bucket or flight elevators also are satisfactory for loading high moisture grains

The best angle of elevation for an all purpose handling of silage is about 45° At that elevation delivery height is 7/10 of the elevator length Extra length usually must be provided, however, since the ground often slopes away from the base of the silo and the elevator should extend well over the edge

Unloading Grain Silage For removing the grain, airtight silos must be equipped with some form of mechanical unloader which can be sealed when it is not in use The chain-type unloading conveyor with which the glass lined silos are equipped works as well with either ground ear corn or shelled corn as it does with forage silage Augers are used often to move materials They consist of a screw device within a tubular housing, as the screw turns, the material is forced through the tube Auger unloaders may be employed, although the auger unloader generally is used on shelled corn only Other silage materials and ground ear corn tend to bridge excessively

Shelled corn does not bridge seriously if it is not cracked considerably or if its content of moisture is not above 30 per cent In ear corn it is best, as a rule, to let the moisture decrease to about 25 per cent During storage the kernel absorbs moisture from the cob Hence ear corn with over 25 per cent moisture becomes too sour and too watery for easy handling A small load of dry grain placed over the auger before filling the silo with the high-moisture material will help start the flow of the grain on the initial unloading Removing a few bushels every week or two during the storage period will prevent the building up of bridges

Some silos are equipped with two or more horizontal auger tubes in the floors Each of these tubes has three or more openings along its length any one of which can supply grain to the auger If one bridges, it is likely that another will work The outlet of the auger is fitted with a cap so it can be sealed airtight

Importance of Silo Strength Most existing silos were constructed before grains or grass silage became popular, and hence they were designed for whole plant corn or soybean silage only. They may burst if filled with high-moisture hay crops or grain. Usually, however, if the footings are sound, the interior has not been pitted extensively by acid, and reinforcing is tight and free from flaws, no trouble is likely to occur. For stave silos it is important to check the exterior reinforcing hoops and replace any which are not strong and capable of being tightened. The mortar joints of concrete block silos also must be in good condition They should be coated with acid-resistant material because leaky joints allow acids to corrode the reinforcing. Stave silos are constructed with acid-resistant material at the juncture of the blocks

9 HAY

WE NOTED IN CHAPTER 8 THAT STORED PLANT NUTRIENTS ARE DEPLETED BY the continuation of plant metabolism until a point is reached where the *pH is low enough* for the life processes and the contingent wasting away of nutrients to cease However, hay (dried forage) offers another solution to this problem of nutrient waste, for the *reduction of moisture content* of forage to 20 per cent or less stops the metabolic depletion of stored plant nutrients Thus the drying of forage achieves two desirable results in one bold stroke (1) the metabolic depletion of stored plant nutrients is curtailed and (2) the dry-matter content of the feed is increased significantly

Curing is defined as the drying of forage to a moisture content which stops chemical and bacterial actions including heating and respiration, with accompanying effects on flavor, aroma, and nutrient content The moisture can be removed in the field by the action of the sun and winds, by mechanical dryers, or a combination of the two While the hay is drying the sugars and proteins react with each other and with other plant nutrients to form products of fermentation and other compounds that give hay much of its fragrance and flavor

Since most of the nutrients in forage plants are stored in the leaves, good hay is leafy and has fine stems It must have been cut early, cured rapidly, and kept dry Such hays will be green in color, highly digestible, palatable, rich in protein, high in minerals and will contain considerable amounts of carotene which is the precursor of Vitamin A

Legumes have more leaves per unit of dry forage than do other plants For this reason they are considered more valuable as hay crops than are grain plants or forage grasses Young plants of other species contain enough leaves to make good hay however, and most grasses, including small grain crops, are so used Moreover, grasses are easier to cure than are legumes because the leaves are less likely to shatter

Hay is the most popular stored roughage because it is relatively easy to handle It can be stored or transported long chopped, pelleted, or in various types and sizes of bales Modern equipment including durable, easily operated mowers, conditioners to hasten drying time, and auto-

mated systems of handling hay has kept interest in this type of feed strong. Thus it is the roughage most often purchased by dairy managers who need more than they can raise.

Since good hay will be consumed to an extent of three or more pounds per 100 pounds of live weight daily, it is easy to understand why hay is regarded as one of the best feeds available for all classes of cattle. Like silage, it can supply the entire requirement for protein, minerals, vitamins, various unidentified factors, and a large part of the energy needs Although hay is easier to feed and store than silage, there is somewhat more risk in the making of hay. Thus we find that some dairymen use one, some the other, but many use both hay and silage. In fact, it is not unusual now to see dairy cows being pastured, and in addition fed silage, greenchop, and hay. Moreover, hay is a good supplement to any or all of the succulent feeds because it induces the cattle to consume additional dry matter.

HAY MAKING: GENERAL REQUIREMENTS

Achieving good quality hay involves an understanding of the general requirements of the process and the product. The apparent simplicity of hay making is somewhat deceptive, since considerable knowledge, alertness, and skill are required to produce quality hay In addition, one must always be on guard against large-scale loss such as can be caused by rain.

Therefore, before considering the role of mowing machines and the industrial aspects of processing hay, we will seek to go beneath the surface to determine the general requirements of the hay-making process. Such a discussion in effect constitutes the fundamental principles of hay making. The general requirements of hay making are determined by such factors as type of plant, conditions of growth, maturity at cutting, effect of rain, and speed of curing

Type of Plant

Although the value of hay is determined by many factors, one of the most important is the type of plant. Legumes contain 40 to 50 per cent of their dry matter in the leaves. This is the part of the plant which is highest in protein, lowest in fiber, and most easily digested. The grasses seldom contain over 30 per cent of the total dry matter in the leaves. On the other hand, grasses retain the leaves much better under conditions of curing and handling.

Some plants cure easily, whereas others are especially difficult to dry Since coastal Bermuda grass is very springy, it holds itself apart, allowing air to circulate freely, and thus drys rapidly. White clover, on the other hand, is limp and hence it tends to pack together and remain wet unless

special techniques are employed These techniques include crushing the stems by mechanical conditioners the use of swath fluffing machinery to loosen the wet forage so air can circulate and artificial drying Such methods may be utilized in the making of good grass hay also

Conditions of Growth

Environmental factors often make more difference in hay quality than does the type of plant Some grasses (for example pangola Bahias and some Bermudas) may contain as little as 1 per cent crude protein or as much as 20 per cent depending on the rate of nitrogen fertilization If factors (such as lack of nutrients unfavorable temperatures inadequate bacterial inoculation soil compaction weed competition drought mechanical injury etc) limit the performance of plants they tend to increase in fiber and decrease in content of soluble nutrients This is because of immature stimulation of impulses favoring reproduction rather than the storage of nutrients

Maturity at Cutting

Maturity at cutting can make a marked difference in the quality of hay Although immature forage has a higher percentage of leaves and consequently a higher percentage of available nutrients than does older forage stems frequently develop so fast that a hay crop requires close observation In fact a difference of a few days in growing time is likely to make more difference in quality than is the species of the plant Thus early cut grass if it is well fertilized may contain a larger percentage of nutrients than legumes in late bloom

Experiments in Canada with red clover have shown that in an eleven day period (from the time heads began forming to the early bloom stage) there was an increase of 30 per cent in the weight of stems with a corresponding loss of leaves This observation appears serious when one considers that leaves contain at least three times the nutrients found in stems (see Table 9 1)[1] Moreover experiments in England[4] demonstrated that the feed value was affected more by cutting dates than by method of hay making except under extremely adverse conditions (Tables 9 2 and 9 3)

Workers in the U S Department of Agriculture[2] investigated the effects on milk production of alfalfa hay cut at three stages of maturity The hay was made when the alfalfa was just beginning to bloom at half bloom and in full bloom The hays were fed to comparable groups of cows over a 12 month lactation period A summary of their results is shown in Table 9-4

Work at Cornell University[3] and at the U S D A Station Beltsville Maryland has shown that cutting date in these areas is one of the most

Table 9-1 Proportions by Weight of Leaves and Stem in Hay from Red Clover According to Stage of Maturity When Cut

Stage of Maturity When Cut	Days Between Stages	Leaves and Fine Stems (%)	Main Stem (%)
Prebudding	—	75	25
Budding	5	51	49
Early bloom	11	34	65
Full bloom	10	30	70
Heads brown	18	25	75

important factors in forage quality (Table 9-5) The productive energy (TDN) of first-cutting forage appeared to decrease by 0 5 per cent per day of delay after June 1 in the harvesting of first-cutting forage in New York state Digestible protein decreased also, as shown in Table 9-5

Naturally some compromise is necessary The most nutritious hay could be made from grass cut at the height of most lawns, but obviously this would not be practical Generally, for grasses and legumes, early bloom is suggested as the proper time for harvest One reason for waiting so long is the general belief that this is necessary to proper conservation of reserves in the roots It is true that nutrients are stored in the roots so that the plant can be kept alive during the dormant period and in condition to put out new growth at the inception of the growing season However, the practice of harvesting at early bloom seems questionable, since blooming plants take nutrients from the leaves for reproductive functions, thus resulting in a decline in the quality of the hay that is harvested for animal usage Moreover, higher annual yields often are obtained by harvesting plants during the prebloom stage

At the Florida Station, for example, alfalfa has yielded nine cuttings per year when cut in a prebloom stage The total yield of fresh material has averaged 31 5 tons per acre annually Should this practice be avoided because it depletes the reserves to an extent that often makes annual planting necessary? This question is certainly open to discussion, and the decision should be different for different locations and conditions The principle, however, is the same *Young plants have more leaves and thus more nutrients than do older plants of the same weight*

Effect of Rain

Forage which still contains most of its natural moisture is not damaged by rain After the herbage has dried, however, rain very seriously decreases the value, particularly of legumes, by knocking leaves off and leach-

Table 9 2 Organic Matter Digestibility of Hays, 1958 and 1959*

Treatment	Cutting Dates								
	1958 (heavy rainfall)			1959 (light rainfall)					
	June 6	June 17	June 25	May 4	May 12	May 21	May 28	June 10	June 15
Grass, frozen at cutting	73.0	67.0	62.2	80 6	79.9	75.7	75.1	71.1	68.0
Barn dried	69.6	57.5	57.7	78.3	76 6	70.7	75.0	69.8	66.8
Rack-dried	66.4	58.4	55 8	—	—	—	—	69.1	67.6
Swath made	64.7	50.3	45.5	76 2	72.8	71.2	68.5	66.9	63.8
Mean	68.4	58.3	55.3	78.4	76.4	72.5	72.9	69.3**	66.2**

*Shepperson, G., 1960. *Proceedings 8th International Grassland Congress*, p. 139.
**Mean, excluding rack-dried. (Means, including rack-dried = 69.2, 66.6.)

Table 9 3 Crude Protein Content of Hays, 1958 and 1959*

Treatment	Cutting Dates								
	1958 (heavy rainfall)			1959 (light rainfall)					
	June 6	June 17	June 25	May 4	May 12	May 21	May 28	June 10	June 15
Grass, frozen at cutting	11.1	9.5	7.5	15.2	14.2	9.1	11.9	10.3	7.8
Barn-dried	10.8	8.5	8.6	13.8	12.9	12.1	11.5	10.7	7.6
Rack-dried	10.6	9.2	7.2	—	—	—	—	10.1	7.1
Swath made	9.5	8.4	7.8	14.3	11.2	8.6	8.1	7.9	5.5
Mean	10.5	8.9	7.8	14.4	12.8	10.3	10.5	9.6**	7.0**

*Shepperson, G., op. cit.
**Mean, excluding rack-dried. (Means, including rack-dried = 9.8, 7.0.)

Table 9-4 Composition, Yield, and Milk-Production Characteristics of Alfalfa Harvested at Three Stages of Maturity (3-year average)*

	Initial Bloom	Half Bloom	Full Bloom
Leafiness (%)	46.0	46.0	41.0
Protein (%)	18.2	18.3	15.7
Fiber (%)	28.9	28.5	32.7
TDN (%)**	59.0	56.7	53.9
Protein yield per acre (lbs)	1427.0	1381.0	977.0
TDN yield per acre (lbs)	4660.0	4413.0	3269.0
Gain per day (lbs)	+0.08	+0.17	+0.01
Average daily FCM (lbs)	27.9	23.6	20.8
DM per day (lbs)	34.9	34.8	33.6
FCM per 100 lbs DM (lbs)	79.9	67.9	62.0
FCM per acre (lbs)	6194.0	5145.0	3814.0

*From *U.S. Dept. Agr. Tech Bul.* No. 739, 1940.
**Digestion coefficients determined with sheep on the 1937 crop only were applied to the data for the entire three years.

ing nutrients Since the leached nutrients are soluble, they constitute the most valuable part of the hay Grasses also are depreciated by wetting but to a much lesser extent than legumes if the harvest is managed carefully

Grass hay, particularly if it has been cut with a dull rotary mower or flail harvester and/or has been crimped or crushed, dries quickly with a minimum of leaching of nutrients and almost no shattering of leaves An effective procedure for saving grass hay which has become wet by rain is discussed later in this chapter (page 121) in conjunction with the discussion for field handling fresh forage

The effect of rain is especially pronounced if it falls while the herbage is in the swath (refer again to Tables 9-2 and 9-3) Of course, decreased quality in wetted forage is due partly to the prolonged exposure These data show that during the curing process, hay always sustains some loss of organic matter, thus artificial drying results in superior feed by speeding the process and by making extra handling of unbaled forage unnecessary The difference in hay quality, however, is not of sufficient magnitude to justify the extra expense of artificial drying except in a very wet season

Speed of Curing

Since it has been shown that plant metabolism continues in forage after it has been cut and that metabolism can deplete large amounts of nutrients,

Table 9 5 The Nutritive Value of Forage as Related to Date of Harvest*

Cutting Date	Nonlegumes			Legumes		
	Growth Stage	TDN (%)	Digestible Protein (%)	G owth Stage	TDN (%)	Digest ble Prote n (%)
			First Cutting			
June 1	Vegetative	70	13 5	Vegetat ve	70	18 7
June 15	Early head	63	10 0	Bud	63	14 5
July 1	Full bloom	56	6 7	Bloom	56	10 2
July 15	Mature	49	3 7	Mature	49	6 4
			Aftermath Following Regrowth for 5 to 9 Weeks			
		58	10 0		58	14 3

*Reported by J T Reid Cornell University

the advantage of fast curing to stop this waste is obvious In fact, rapid reduction of the moisture content is *essential* to efficient preservation because plant enzymes that deplete stored nutrients cannot act without considerable moisture Moreover, respiration and other physiological actions which occur at the expense of plant nutrients are terminated by drying However, it should be noted that as soon as life processes cease, microorganisms act on the plant nutrients until further drying inhibits their activity Unfortunately, this type of fermentation causes considerable loss of nutrients and heat This not only depreciates the quality of the hay but the heat could result in fire

Drying forage artificially will preserve more of the nutrients, but often the question is raised, "Doesn't curing hay mean something more than drying, and isn't the other part of curing desirable?" Ordinarily, changes other than dehydration do occur in the curing of hay These changes take place as a result of *chemical* actions which deplete nutrients They enhance the aroma and flavor, however, making a definite answer to the second part of this question impossible It might be said that changes in the carbohydrates and proteins which help flavor are desirable so long as hay retains most of its green color

Browning Hay which has gone through heat and turned brown often is relished by livestock They will eat it in preference to green, leafy hay which is much higher in productive nutrients The fermentation and browning processes which affect proteins and sugars cause caramelization, which gives the hay a desirable flavor but at the expense of the most valuable of the nutrients Good hay has much of its original color

Since a certain amount of change due to chemical, enzymatic, and metabolic action occurs even under the most favorable conditions, it is best to remove moisture from forage as quickly as possible, leaving the browning process to nature

Hay Conditioners Since hay must be made as quickly as possible, conditioning by such methods as crimping, crushing, or frazzling the stems can play an important role

Equipment used to score or crush wet forage liberates moisture from the stems, and this can speed the drying process tremendously Hay conditioners now are fairly simple machines which run the forage between rollers or crimpers (Figure 9-2) They are highly desirable additions to any system of haymaking, as noted previously, they can be used to help condition forage which is to be ensiled

Artificial Drying. When hay is cured by artificial heat and/or forced air, usually a large part of the moisture is first allowed to transpire naturally in the field for reasons of economy Thus, with most systems, really severe weather still prevents haymaking The chances for haymaking are

many times more numerous in an average year, however, if equipment for removing part of the moisture artificially is available Most systems now in use employ heated forced air, the hay that is being dried may be in round or square bales or loose

Some systems operate by forcing hot air through tunnels to all parts of the enclosure thus allowing it to rise through the whole mass of hay at once However, when air is forced upward into the lower areas of the system often it escapes around the relatively loose top bales, instead of passing through them Consequently, they are left wet However, other systems put the heated air in at the top forcing it downward through the hay (Figure 9 1) When this type of system is used, a chamber at the top for collecting and compressing hot air is desirable The initial force of the

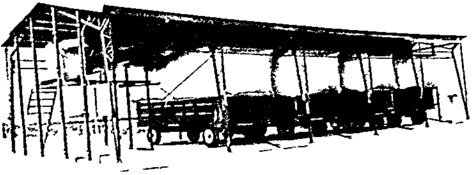

Figure 9-1. Slat floored wagons and an inexpensive pole building, together with a source of heated forced air, make an excellent system for drying forage or grains Small bales may be stacked at random and dried on the wagons with this equipment (Courtesy New Holland Machine Co)

air drys the top bales Naturally the hay close to the floor is well compressed and hence the air must go *through* rather than around it Thus when the air enters at the top there is less chance that some bales will be bypassed Nonheated air is used in some locations but heating the air is highly desirable in all systems unless relative humidity is very low

MOWING MACHINES

The increased use of grassland has stimulated engineering improvements in mowing equipment Thus many different versions of both rotary and sickle bar machines are available for conditioning pulverizing cutting and windrowing cutting and leaving forage in the swath and even for scatter

ing droppings in pastures These machines may be mounted on the side, rear, or under the tractor, or may be pulled behind Some of the rear-mounted rotary mowers can be picked up hydraulically and placed precisely when desirable, as in the fenced corner of a pasture Some are driven by friction of wheels rolling over the ground like push-type reel lawn mowers Others are powered by the tractor In general, they operate more smoothly and are made of more durable materials than machines of a decade ago

Sickle-bar Machines

The sickle-bar or cutter-bar principle has been in use for close to a century The cutter bar is the vital part of such machines, and consists of a sectioned knife which slides rhythmically to and fro at an angle of 90° to the direction of travel of the machine The forage is caught between guards which hold it until it is cut by the corresponding knife section

Improved designs and more rugged materials developed during the past decade have resulted in new sickle-bar machines which are so well balanced that they operate with almost no vibration and thus may be used for long periods with little maintenance Clogging of the cutter bar with forage virtually has been eliminated by means of special guards and double sickles Fast-hitch also has made these machines practical The mowing machines can be attached or removed from the tractor in a few minutes, whereas only a few years ago several hours were required for the job Of course, the tractor remains free for other jobs when actual mowing is not being done

At one time there was a trend to combine crimpers or crushers with sickle-bar mowers so that the forage could be cut and conditioned in a single operation with one machine However the new sickle-bar machines move very fast, and the trend has been away from such combinations even though credible mower-crushers still are available Now most conditioning in connection with sickle-bar cut forage is done by pulling an additional machine behind the mower (Figure 9 2) Since modern crushers and crimpers are much simpler than machines of a few years ago, they can be pulled easily by the same tractor that does the mowing Moreover, since their action requires no very fast moving parts, friction drive is quite satisfactory for these machines

Flail Choppers and Rotary Mowers

Using the flail harvester for conditioning hay requires considerable skill, particularly if the forage is a legume The ground speed and speed of the rotor (and flails) must be coordinated If the relative ground speed is too slow the forage may be chopped so much that the pieces mat together,

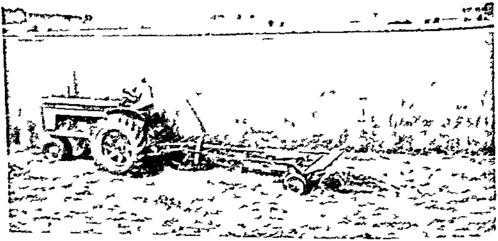

Figure 9-2 Mowing and conditioning hay simultaneously with two pull behind machines (Courtesy New Idea Farm Equipment Co)

restricting the movement of air For this reason these machines were not used extensively for legumes until flail harvesters were made especially for hay If the ground speed is too fast the stubble is ragged and drying time is not reduced as much as it should be

In grass a somewhat faster job can be done with a rotary mower than with a flail machine Both are slower than sickle bar mowers however Rotary machines can be used for cutting legume hay crops if the blade is very sharp In this case the forage is cut but not conditioned by the blade

In the case of grass crops the rotary mower conditions the forage in much the same way as the flail harvester The stems are frazzled and split and the leaves usually ripped lengthwise several times For this effect the blade must be no sharper than is necessary to avoid merely knocking the grass over without cutting it The conditioning of grass results in this instance because a relatively dull blade beats rather than cuts the forage from the ground

After the conditioned grass has lain in the swath for from one to two hours a thin film of dry hay may be seen at the surface This dry material is rather stiff and springy If the forage is raked or if a swath fluffer is used at this time the dry forage will be mixed with that which still is wet Then because of its springy physical characteristic the dry grass will hold wet material apart giving a rather fluffy appearance to the forage (Figure 9 3)

In good weather circulation of air will finish the curing in another three to four hours.

Field losses with either of these machines will be one to three per cent higher than those that occur with crushed or crimped hay. Still the labor and equipment cost is less, and under some conditions drying is faster than with more conventional methods and machines Moreover, crushers can be used on forage cut with rotary or flail harvesters. Crimpers help by fluffing the cut material, although usually the rotary or flail-cut forage particles are too short to be conditioned further by crimping.

The same procedure described for field handling fresh-cut forage is effective in saving grass hay wet by rain. About two hours of sunshine will dry a thin layer on top of the forage. Raking mixes this dry material into the forage to produce a fluffy mass permitting free circulation of air and quick drying The main loss is due to leaching, and this is held to a minimum. Several rains, however, can cause severe damage. Still, rain on pangola hay every day for a week at the Florida Station did not completely ruin the crop because it was raked after each wetting The forage was clean-smelling and retained a considerable part of its green color. Approximately two thirds of the protein content was leached, however

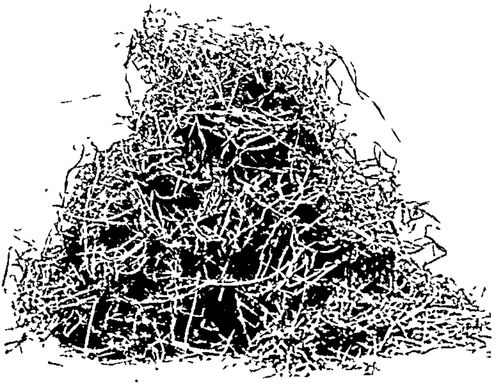

Figure 9-3. Rotary-cut hay showing ripped stems and shredded leaves.

Somewhat the same procedure can prevent total loss in rain-damaged legumes Leaching always is more extensive than with grass, however, and usually mechanical loss of leaves occurs at each raking after the first

THE FEED INDUSTRY AND DAIRY MANAGEMENT

Dehydration

The forage dehydration industry processes over a million tons of hay (mainly alfalfa) yearly in the United States Generally, high quality forage is purchased in the field Under this system, all processing including the harvest is done by the companies The processes although expensive are feasible because the products can be used as special supplementary feeds They are especially high in carotene, Vitamins E and K, and unidentified nutritional factors for growth and reproduction After dust depressants and antioxidants are added these products are sold as a meal or pellets

Pelleting

During recent years interest in pelleted hays has increased considerably because pellets can be handled mechanically Moreover, as much as three times as much roughage can be stored in a given area than is possible with baled hay Of course, the storage facility must be stronger About the same pressure is exerted by pellets as by such concentrate feed ingredients as oats or citrus pulp Pellets keep well in dry buildings, but will expand somewhat if stored in a humid place

Methods Pelleting is accomplished on cured hay only Any method of curing is satisfactory, but in commercial operations dehydrated hay is used The dry forage is ground very finely and pressed into small balls or cylindrically shaped pellets

Many feed mills will pellet hay on a custom basis Since the price is reasonable, the question of whether or not to make use of this service is determined largely by transportation costs

Roughages (including hay or whole plants of corn, milo, and the like) can be pelleted on the farm, whether or not it is practical depends upon the cost Some large operations use stationary pelletizers that handle only dry forage However, since field-curing is uncertain artificial drying equipment should be available also The pelleting machinery works very fast, but the operation can be kept continuous by the incorporation of a dehydrator Thus as green forage is put into the dehydrator, the operation continues automatically by having dry forage fed into the pelletizer Since pelleting machinery is expensive one is justified in using the best hay available Although dehydration is the fastest and hence the best method of curing hay for pelleting any dry roughage can be pelletized

In some states custom operators pelletize feeds at the customer's farm The cost generally is high, but many dairymen feel that it is feasible, since pellets fit into their operations better than other forms of roughage

Field-pelleting machines apparently soon will be avialable to the individual farmer at reasonable prices Probably they will process only dry feed, which will leave the dairyman where he started with respect to curing problems

Effect on Digestibility and Appetite Any effect pelleting may have on digestibility of hay probably results from the increased density of this form of feed One of the functions of the rumen is to increase the density of feeds, for heavy materials gravitate forward and pass into the omasum Particles which are light, however, float on top of the rumen fluids, and as the cow ruminates, they are rechewed until dense enough to sink upon being reswallowed

Since old, fibrous hay is tough and difficult to reduce into small particles, it has to be regurgitated and rechewed very extensively However, good quality roughage is easy to chew and the particles absorb saliva and rumen fluids quickly Moreover, tender forages are fermented more easily than fibrous feeds, thus they move out of the rumen quickly

The most important difference between good and poor quality roughage is the speed with which good roughage can be digested Since pelleting increases density, pelleting or grinding tends to make good and poor quality forages more nearly alike However, the digestibility of good quality forages might be reduced slightly by pelleting, since pelleted forage moves through the rumen more rapidly than does long forage

Poor quality forage is speeded through the digestive tract also However, less time in the rumen does not mean less digestive action than occurs with poor quality forage in the long state This is because rumination time for such fibrous hay is concerned mainly with reducing the size of the particles On the other hand with ground or pelleted hay, this work is done for the cow, and thus she can consume more of the preprocessed feed If the processing affects digestibility of poor hay at all, digestibility is likely to be increased because of the exposure of a greater surface to digestive processes

In general, more roughage is consumed by cattle when pellets are used in place of long or chopped hay This may be partially because pellets do not result in sufficient rumen-fill to help in suppressing the appetite Whether this effect is desirable in dairy cattle remains to be seen Dairymen in areas of congested population often have difficulty securing leafy roughage and use bulky concentrates instead This often has caused the large breeds to quit ruminating and to go off feed

With plenty of succulent leafy roughage available, cattle are frequently very selective of other feeds Under such conditions, high producing cows

at the Florida Station refused small, hard alfalfa pellets and rejected most of the mixed concentrates offered Very bulky concentrates were eaten readily, however When succulent leafy roughage is plentiful, the use of larger, softer pellets or wafers seems advisable

Effect on Milk Fat

For many years it has been known that small, hard pellets when given as the only feed cause cows to produce milk abnormally low in fat content In fact, it is not unusual for fat content to decrease by half or more within a few days after long roughage is restricted Nonfat solids, however, are not so easily affected by feed

The composition of milk seems to be influenced by bacterial action in the rumen Thus the organisms of the rumen attack fiber to obtain energy, and the by-products produced (largely acetates and propionates) are precursors of butterfat The ratio of acetates to propionates normally is close to 3 1 Pelleted hay moves out of the rumen too quickly for bacterial fermentation to proceed as far as in the case of long forage Thus when pellets are fed, more of the bacterial action is on soluble carbohydrates, resulting in a narrowing of the 3 1 ratio A narrow acetic-propionic ratio in the order of 1 1 is likely to result in abnormally low fat percentages It seems probable that acetates are the main fat precursors and that propionates and perhaps similar compounds control the hunger reflex They are useful in other ways also, since all fatty acids can be utilized for energy In fact, some narrowing of the acetic-propionic ratio could be valuable, since when the acids or their salts (the acetates and propionates) are used for energy, propionic acid has a smaller SDA than does acetic acid

Alternatives

No one hay-processing system is best for all dairies Some dairymen cut small amounts of grass at a time, letting cattle pick it up from the swath Cattle will do this even if lush succulent forage is accessible, since the action of wilting causes a concentration of sugars and permits enough fermentation and chemical action to make the forage very palatable

Hay may be harvested in the form of bales as small as 12 inches in length, which can be dumped, piled, and handled for the most part by machinery (Figures 9-4 and 9-5) Although small bales may be ensiled, conventional-sized bales of silage are too heavy to handle and baled silage is not ordinarily used

Self-feeding hay driers and silos are practical for some operations The feed is consumed from the structure in which it is stored When structures resembling upright silos are employed to cure chopped hay, the forage handled is partially dried in the field and curing is finished by blowing hot

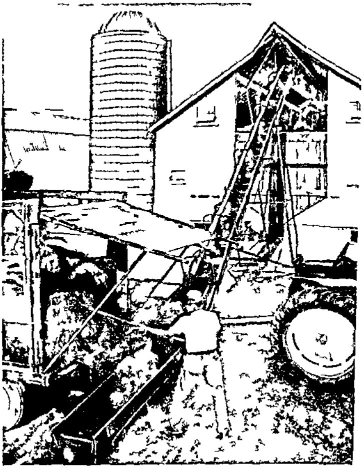

Figure 9-4 Small bales are handled by one man using modern equipment (Courtesy Deere & Co)

Figure 9-5 Self propelled hay cruiser bales and loads hay using the labor of only one man (Courtesy New Holland Machine Co)

air into the partially dry mass As the structure is filled closer to the top the hot air can be directed away from the dry material in the bottom and blown directly into the forage to be cured As cattle eat from the bottom of the drier the hay feeds down automatically Most bridging is prevented by a large cone in the bottom which keeps the dry hay from slipping downward and outward to the feeding area In addition bunker silos are adapted easily to self feeding by an arrangement of movable ends through which the cattle can reach In this way fresh silage can be kept available

Although part of the feed may be wafered and the other forage used as long chopped or baled hay or silage additional research relative to the effects of the physical form of roughage on its nutritional value is needed Moreover the nutritional importance of the density of feed has not been fully examined What effect continuous feeding of pellets will have on rumen tissues how tightly compressed pellets should be how steam treatments rolling and grinding influence rumen bacterial action and the need for a simple chemical test which is reliable enough for general use in evaluating forages (the most promising one at present is the artificial rumen technique described in Chapter 3) represent some areas in which our knowledge is incomplete The continued advance in automation and the cost of labor make it reasonable for modern dairymen to plan to handle most of the feed by machinery Such material may be utilized in the form of long ground chopped pelleted wafered or baled hay or silage or perhaps in some other form or preserved state not yet invented

In any concentrate (standard or special) the concentrated portion is mainly the energy producing nutrients expressed as TDN or net energy Among the standard concentrates the grains ordinarily contain 70 to 80 per cent of TDN Also the by products resulting from the processing of cereal grains for human use supply high energy feeds for livestock Thus the cereals and their by products (mill feeds) provide a large portion of the standard concentrate feeds Other standard concentrates such as whole grains and by products of the citrus and sugar industries are even higher in TDN since they have high energy nutrients such as fats and soluble carbohydrates in large proportions On the other hand many of the by-products of the milling vegetable oil, brewing and distilling industries are high protein special concentrates which are used as protein supplements

Since the classification of 'standard' or "special" is based merely on a semantic distinction no effort will be made in the present chapter to pin point the various concentrates in a feed mixture as either standard or special These rather artificial categories have only been employed for convenience in articulating a basic concept and are in no sense all inclusive

In general the constituents of a concentrate mixture are formulated in terms of the prime purpose of supplementing forage although secondary functions may be served also Thus mineral matter although producing no energy in the body is needed to supplement roughage and grains Hence it is usually included in the concentrate mixture The amount and type of mineral supplement required are determined largely by the nature of the soil on which the other feed in the ration was raised Although urea furnishes no energy and no protein per se it is often included in the concentrate mixture since rumen organisms can under certain conditions utilize urea to make protein

Some of the bulky concentrates such as crimped oats citrus pulp beet pulp or flaked soybean hulls often are included in roughage mixtures used to supplement regular concentrates in areas where leafy feeds are very expensive In addition these mixtures usually contain ground or chopped hay ground corn cobs cottonseed hulls or some other feed which is high in fiber Bulky concentrates are particularly well suited for supplementing high moisture forage

THE CONCENTRATE MIXTURE CONSTITUENTS

Energy Source the Cereal Grains

The grains produced by specialized plants of the grass family supply the largest portion of the concentrate feeds By far the most extensively used concentrate is corn The part utilized most frequently is the whole kernel

In the case of mature cattle, these grains need to be ground or cracked, otherwise they could pass through the digestive tract unchanged The entire ear, including the shuck, often is ground and used in the South, in the North corn and cob meal is used without the shuck In these forms (which include cob and sometimes shuck) corn is a bulky concentrate

Other important cereal grains are wheat, barley, sorghum, milo, rye, buckwheat, millet, emmer, and spelt The characteristics of these plants and numerous other feeds have been described in detail, by Morrison[5] and Schneider[6] In general the cereal grains and their by-products are high in starch and low in fiber, although some (such as oats) are quite bulky Usually they are low in protein, and the protein that they do contain is of poor quality All grains are low in calcium None of them contain appreciable amounts of vitamins needed by dairy cattle, although yellow corn can be an important source of carotene, the precursor of Vitamin A In general, these feeds are used as a source of energy

Fiber and Digestible Energy the Bulky Concentrates

The designation "bulky concentrates" is suggested for that in-between group of feeds which is high both in fiber and in digestible energy Examples of these feeds are citrus pulp, ground snapped corn, apple pumice, flaked soybean hulls, and beet pulp Brewers grains and distillers grains may also fit into this group, but they are further distinguished by being medium in proteins (over 20 per cent) They are often chosen when bulk and protein are both desirable

All bulky concentrates are frequently used in roughage mixtures, and bulky concentrates are sometimes called roughage The danger in thinking of them as roughage, however, is that the bulky concentrate feeds occasionally are substituted for leafy roughage This can lead to serious physiological complications unless special precautions are taken, since essential factors are contained in the leaf Nevertheless, bulky concentrates are extremely valuable feeds when employed with leafy roughage

Supplementing Leafy Forage. Some leafy plants are very low in fiber, and their value can be enhanced considerably by supplementary bulky concentrates These include many of the succulent low-fiber plant species which are widely utilized for grazing, greenchopping, and ensiling Examples are clovers, alfalfa, pearlmillet, and the green forage of such small grain crops as wheat, rye, and oats When these forages are in a vegetative stage, they often contain 3 per cent or more of digestible protein on a fresh basis, and cattle have been observed to consume as much as 180 pounds of total forage per 1000 pounds of body weight daily, 120 pounds is not at all unusual

High consumption rates of forages are desirable because such feeds are

economical sources of nutrients Even though they are very low in fiber and high in moisture, the dry matter that they do contain is highly digestible In fact, cattle will eat large amounts of succulent forage and take in more nutrients from this source than from hay or silage Moreover, animals grazing on leafy roughages often consume from this source alone protein in sufficient amounts for body maintenance and production of 60 pounds of milk daily The problem is that the forage is low in energy-bearing nutrients, supplying only enough to support production at a level of about 20 pounds daily Thus the main problem in using most high moisture forages is in getting enough TDN into the cows

Although a cow with a rumen full of forage is not likely to be hungry, she may still need considerably more feed to meet her nutrient requirements for maintenance and production Thus the tendency of cattle to eat large amounts of forage has its drawbacks As previously indicated, leafy forage is low in dry matter which contains all of the energy-bearing nutrients When cows are limited to the usual concentrates (which are not particularly bulky), they do not consume enough dry feed and production drops off

Often cows will graze so heavily that they refuse to consume the usual nonbulky concentrates Many herd managers have been delighted by this, since concentrates are ordinarily the most expensive part of the ration However when the cow stops eating concentrates, production drops off rapidly due to energy deficiency, frequently with accompanying digestive disturbances resulting in scouring Strangely enough, this does not cause the cows to consume less of the succulent forage and their appetites for concentrates continue to be depressed Yet cows with free choice of high quality leafy roughage often also eat bark, leaves from trees, Spanish moss, and such fibrous weeds as they can find Succulent forage seems to cause a craving in cattle for very rough feeds but high consumption rates of the succulent feed usually goes on and productive functions continue to diminish unless special techniques in ration formulation and/or feeding are employed

Feeding of hay in addition to succulent forage, especially if it is of good quality, provides some help by increasing dry matter intake within limits Although enough hay to prevent scouring will usually be eaten, it is generally consumed in insufficient quantities to fulfill the cow's need for energy

Because there seems to be a craving for coarse high energy feeds the bulky concentrates are eaten readily by cattle fed freely on succulent forages In fact, coarse bulky high fiber high energy feeds often are the only supplementary feeds which cows with free access to succulent forage will eat in adequate amounts *When bulky concentrates are used they cause the scouring to stop and supply the additional energy needed as well as extra proteins*

A system which can be used to induce cows to eat concentrate feeds that are not bulky in addition to succulent forage is to hold them in a dry lot for about two hours before each milking When this is done, they become hungry because the rumen empties quickly Then they will consume non-bulky concentrates Cattle sometimes become conditioned to the effects of succulent forage and do consume regular concentrates in addition to the green leafy roughage even without being held in dry lots They cannot be relied upon to do so before production decreases, however Even when so conditioned, cattle at the Florida Station have shown a marked preference for bulky feed as a supplement to succulent forages

Mixtures of bulky concentrates may be employed to lighten the feed and make it free-flowing (Figure 10-1) The small grains such as oats, wheat,

Figure 10-1. The concentrate mixture usually is bulky enough to prevent compaction.

rye, and barley are valuable for this purpose and as a supplement for succulent forage However when the small grains are employed as feed for cattle, they should be crimped, otherwise, many of these small fibrous seeds are likely to get through the digestive tract intact Crimping oats is an effective way to insure adequate contact with the digestive process without depleting the bulky nature of the feed [1]

Although wheat bran is excellent for increasing the bulkiness of concentrate feeds, it is rather laxative, and thus not suitable as a supplement for succulent forage which is laxative also

The high moisture forages have a reputation for limiting milk production and they will do this when the total feeding program is mismanaged How ever when correct concentrate formulations are used and properly timed feeding is practiced these roughages often supply more nutrients than good hay or silage

Protein Supplements

In order to properly balance most feed mixtures extra protein must be added Thus feedstuffs alone or in mixtures which supply mainly protein are known as protein supplements Usually the ingredients chosen to sup ply extra protein are the by products of a processed feed that result from the removal of nutrients other than proteins from the feed

The Oil Meals The protein supplements derived from oil bearing seeds are known as oil meals Their protein content is concentrated because the oils have been extracted They are the highest in protein of all the supple ments ordinarily used for feeding cattle Linseed cottonseed peanut and soybean oil meals are the most popular However sunflower rapeseed and coconut oil meals are employed to some extent and others such as citrus seed meal will be available in the future The oil meals are accessible also in the form of cakes or pellets for pasture feeding Thus they may serve as the sole supplement for dry cows which are fed silage made from corn sorghum oats milo or any other forage which is high enough in energy but low in protein This type of feeding is quite satisfactory for growing heifers

Grain By products Processes of the brewing distilling and milling in dustries remove the carbohydrates leaving the proteins of the original grain in a concentrated state Corn gluten meal is a by product of starch and glucose manufacture It is high in protein content but tends to compact so that it should be mixed with bulky concentrates Corn gluten feed is less concentrated than the meal since it also contains part of the bran and corn kernels

Dried brewers grains and dried distillers grains are palatable bulky medium protein feeds which are excellent supplements to most of the low prqtein concentrates

Relative Value of Protein Supplements It is true that the ruminant can use protein of any quality since the rumen microorganisms change in adequate protein to high quality animal protein However not all of the proteins which a cow consumes goes through these changes In addition some protein can be metabolized more easily than others by the bacteria and protozoa Thus there are differences in the value of proteins from various sources and some of them have been studied [4] These supplements are ranked in the order of decreasing value as follows

(1) corn distillers dried grains
(2) milo distillers dried grains
(3) soybean oil meal
(4) coconut oil meal
(5) corn distillers dried solubles
(6) rye distillers dried grains
(7) brewers dried grains
(8) corn gluten feed
(9) linseed oil meal, old process
(10) linseed oil meal, solvent

In the experiments which determined this ranking, each of the ingredients was used as the only supplement to a basal ration of barley, corn and oats.

Urea as a Substitute for Protein

Chemically, urea is the diamide of carbonic acid, carbamide. For animal feeds it is synthesized from ammonia and carbon dioxide. Its structural formula looks somewhat like protein linkages, but the bacteria probably hydrolyze it to ammonia (NH_3) which is used to synthesize proteins. Thus urease supplied through bacterial metabolism or consumed in the feedstuffs causes ammonia to be liberated, and the bacteria synthesize proteins by reducing the ammonia and combining it with carbon, hydrogen, oxygen, sulfur, and possibly other substances supplied by the feed or rumen syntheses.

$$\mathrm{C{=}O}\begin{cases}\mathrm{NH_2}\\ \\ \mathrm{NH_2}\end{cases} + H_2O \xrightarrow{\text{urease}} 2\,NH_3 + CO_2$$

Thus urea alone cannot replace the proteins. It can supply the amino nitrogen, but the other part of the protein molecule must come from elsewhere. Thus when urea and carbohydrates are supplied together, rumen bacteria combine them and possibly other rumen products into bacterial protein which subsequently is used by protozoa and then by the cow. Of course, some bacteria are digested and absorbed by the cow before they can be used by protozoa.

Urea is 46 per cent nitrogen. Protein averages about 16 per cent nitrogen. Hence, to convert nitrogen which is represented by N, to a protein equivalent, multiply N by 10/1.6 or its equivalent (= 6.25). Hence, N × 6.25 = protein. A pound of urea contains 0.46 pound of nitrogen, thus it is said to be equivalent to 0.46 × 6.25 = 2.9 pounds of protein.

Pure urea is difficult to store and mix and hence it is mixed with an inert carrier which makes it equivalent to 2.62 pounds of protein. However, in 2.62 pounds of protein only the 0.42 pounds of N and negligible hydrogen can come from urea. Hence, 2.62 − 0.42 = 2.20 pounds which must come from other sources which will consist mainly of carbohydrate feeds.

Now the question is how much carbohydrate feed to add. This is attacked easily by an indirect method which also helps answer the question of whether urea is economical. How much of a popular protein supplement

can a pound of urea with appropriate carbohydrates replace? Consider a 41 per cent protein feed. Thus since 2.62/0.41 = 6.4 pounds of 41 per cent protein feed, the inverse is also true and 6.14 pounds of 41 per cent protein feed supplies 2.62 pounds of protein. As mentioned above, this is the protein equivalent of one pound of urea. Hence if the urea-carbohydrate mixture is to be the equivalent of a 41 per cent protein supplement, we simply add for each pound of urea 6.4 − 1.0 or 5.4 pounds of a carbohydrate.

The answer to the monetary question follows easily. If 5.4 pounds of a carbohydrate feed and 1 pound of urea cost less than 6.4 pounds of a 41 per cent supplement, urea should be used, but not if the reverse is true.

Generally speaking, urea is not employed in amounts higher than 3 per cent of the total concentrate feed, though experimentally it has been used at much higher levels. Apparently sulfur supplementation raises the potential level for urea feeding. However, the hydroxy-analog of the sulfur-containing amino acid methionine appeared not to stimulate the growth of young animals eating concentrates which included urea at the recommended level or at high levels in recent Florida tests. Perhaps other supplements will promote the utilization of urea so that future feeding levels of urea can be raised.

Mineral Matter

The inorganic part of the feed, though supplying no energy, is no less important than any other group of constituents. At least 13 minerals are required by cattle.

Common Minerals. The elements often called common minerals are those needed in relatively large amounts. Two of these, potassium and sulfur, are available in adequate amounts in most rations. Magnesium is not often deficient, though specific instances of magnesium deficiency have been reported, particularly on succulent pastures. Frequently dairy rations are deficient in sodium, chlorine, phosphorous, and calcium.

Sodium and chlorine usually are supplied in the form of sodium chloride. The sodium helps maintain proper acid-base balance and may function in muscle metabolism. Chlorine is a precursor of the hydrochloric acid in the abomasum, and is a normal constituent of most glandular secretions and of blood.

Milk contains about 0.54 gram of calcium per pound, and this mounts up to more than high producing cows can consume. Thus calcium is likely to be depleted during lactation. It can be replaced during the dry period, however, and apparently the rapid turnover of body stores of calcium is not harmful.

Under good conditions cows will require at least 1 gram of phosphorous per 100 pounds of body weight daily for maintenance. In addition, 0.7 gram per pound of milk is suggested. Phosphorous deficiency results in de-

of protein Ordinarily, this class of feed is not harmful, but the content of common feeds accounts for most of the benefits if any which it brings about

Sometimes tonics or stock feeds may be toxic because of their content of narcotic drugs such as nux vomica This drug, although habit forming, is included in some stock foods because it quickly brings a healthy looking luster to hair coats The trouble is that the sleek look disappears rapidly when the nux vomica-containing materials are removed from the diet Low levels of this product will not continue to produce the desired effect, and high levels can be harmful

Vitamins

All B complex vitamins and Vitamin K are formed in the rumen in adequate amounts, and Vitamin C is synthesized in the tissues of the cow Hence her requirements for vitamins are limited to Vitamin A which comes from carotene in green leafy feed, Vitamin D which is formed in the skin and forages exposed to sunlight, and possibly Vitamin E which is present in the green portion of most feeds Vitamin deficiencies seldom cause problems in cattle

THE FEEDING STANDARD

A table for each class of livestock which shows what is believed to be the nutrient requirements for maintenance and production is known as a feeding standard Various standards have been employed in feeding livestock for over 50 years

Feeding standards generally have been an attempt to list the economic requirements rather than biological requirements This simply means that safety factors are added to cover such efforts as walking to and from pasture grazing, and metabolic changes which help the animals adapt themselves to alterations in weather planes of nutrition and speed of productive processes How much of a particular feed is practical and how the requirements change as size or production varies are questions which have been controversial, so much so that the resulting confusion has obscured the real purpose of the feeding standard It simply is meant to be a guide that will give the practical manager a starting place in planning a ration By the use of any good feeding standard a ration can be calculated for a typical animal in the herd This feed cannot perfectly meet requirements and thus the modern herd manager after close observation and careful records will often make changes

Of the feeding standards now available the one which appears to apply best to modern American conditions was formulated from all available data by a special committee on animal nutrition for the National Academy of Science National Research Council It is shown in Appendix D

Use of the Feeding Standard

It should be remembered that environment, plane of nutrition, production, and various other factors affect the economic nutrient requirements. *They are not fixed.* Neither is the nutrient content of feeds a fixed value. Each crop of a given grain will be slightly different from the others, and could diverge considerably from the figures in the list which accompanies most of the feeding standards.

The nutrient requirements of livestock may be calculated for the vitamins and minerals to the extent that the animal requirements and feed contents are known. It seems more practical, however, to supply these nutrients in some excess; in fact, this often is necessary for pasture-fed animals. Thus usual calculations are restricted to TDN (total digestible nutrients) and DCP (digestible crude protein), though this is not a rule.

The requirements as shown in Appendix D were used to show the first step in calculating a ration as shown in Table 10-1. When the requirements are determined, the amounts of nutrients supplied by the roughage are calculated. When greenchop, silage, or hay is fed, the amount is weighed. Then from Appendix D the intake of specific nutrients can be calculated. In the case of pasture, an estimate based upon a subjective appraisal of forage quality is necessary. If the pasture is abundant and cattle have free access to it, they will consume forage dry matter amounting to from 1.5 to 3 per cent of their body weight. The high level is reached only in the case of very young succulent forages. Concentrates are selected and evaluated from Appendix D for the balance. Some typical rations meeting the requirements are exhibited in Table 10-2. In each case it was necessary to supply somewhat more than the calculated requirements. This is practical because the requirements are by no means exact.

Table 10-1. Calculated Nutrient Requirements in Pounds for a Cow Weighing 1000 lbs and Producing 50 lbs of 5% Milk Daily

	DCP	TDN
Maintenance	0.60	7.0
Milk	2.50	18.5
Total	3.10	25.5

MIXING FEEDS ON THE FARM

Whether to mix feeds on the farm is determined generally by the amount of feed which the dairyman can produce. The grinding and mixing processes can be accomplished by the feed mills at less cost to the dairyman

Table 10-2 Some Combinations of Feed in Pounds Which Supply the Requirements Shown in Table 10-1

Feeds	Weight	DCP	TDN
Ration A			
Alfalfa hay	20	2.18	10.14
Corn	10	.67	8.01
Citrus pulp	10	.52	7.82
		3.4	26.0
Ration B			
Alfalfa silage (not wilted)	40	1.04	5.40
Timothy hay	14	.42	6.87
Corn and cob meal	10	.54	7.32
Cottonseed meal (solvent)	2	.69	1.32
Oats	3	.28	2.10
Citrus pulp	4	.21	3.12
		3.2	26.1

than would be accounted for by his labor and the interest on his investment in equipment

Where grains are raised in significant quantities (and modern machinery often makes this feasible), home-mixing saves freight to and from the mill as well as the manufacturer's profit Relatively inexpensive machinery does an effective job In addition, feeding grain crops on the farm where they are raised simplifies marketing of the grain

The concentrate mixture should vary somewhat as different types of fresh forage become available The same ingredients should be used throughout if possible, however, and whenever possible, changes should be gradual

Therefore, at the beginning of the season it is desirable to estimate accurately the amounts of various home-grown feeds which will be available For example, one may have twice as much corn as oats Reference to Appendix D shows that corn usually contains about 8 7 per cent protein and 80 1 per cent TDN Oats average 12 per cent protein and 70 1 TDN This TDN is normal for the grain mixture, and protein content will be $(2 \times 8\,7 + 12)/3 =$ approximately 10 per cent, (9 8 is rounded off because these are average figures which are approximate for any given feed) If the feeding operation is extensive, the home mixture should be sent to a laboratory for analysis

If lush alfalfa or clover (and perhaps other palatable legumes) constitute the main part of the forage, the home mixture itself probably would be adequate

When grass pasture or most silage or hays are the main forage, the protein content should be increased Just how much can be determined only by the performance of each herd The usual recommendation of 16 per cent protein ration probably holds when good quality grass also is fed If the forage is poor in quality, perhaps as much as 20 per cent of protein will be necessary This is a controversial question which cannot be resolved until the digestible protein and TDN (or other means of expressing the energy content) which can be consumed daily by typical cattle from forages have been determined accurately

Suppose, however, one decided upon a 17 per cent mixture Obviously a high protein supplement must be added to the home mixture This should be chosen primarily on its cost per unit of digestible protein (again using a standard reference) and from its rank as shown on page 133

For example, the best protein may be cottonseed meal which contains 41 per cent of protein The 17 per cent mixture is calculated as follows draw a square as shown in Figure 10-2 and place 17 (the per cent of protein desired in the mixture) in the middle At the upper left corner place the per cent protein of the supplementary source (41 in the example), at the lower left corner place the per cent of protein in the home mixture (10 per cent for the example of the corn and oats combination) * Now subtract diagonally ignoring the sign $41 - 17 = 24$ Write 24 in the corner just diagonally opposite to 41 Then $10 - 17 = 7$, which goes in the corner diagonally opposite to 10 Now add the $7 + 24 = 31$ Then 7/31 of the mixture will be cottonseed meal and 24/31 will be the home mixture

Suppose it is desirable to mix a ton of feed at one time

Then $16/31 \times 2000 =$ 1032 lbs of corn,
$+ \quad 8/31 \times 2000 =$ 516 lbs of oats,
$+ \quad 7/31 \times 2000 =$ 452 lbs of cottonseed meal

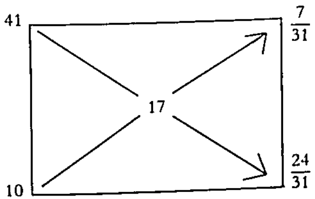

Figure 10-2

*The corn and oats combination is in a ratio of 2 1

Using only data from feeding standards one could devise rations which may not be practical For example too much wheat bran could cause diarrhea Other feeds may be difficult to mix or may be too bulky or unpalatable Table 10 3 shows suggested levels for some of the most common ingredients

Table 10-3 Suggested Levels of Feedstuffs in Pounds to Use in a One-ton Mixture

Feedstuff	Minimum	Maximum	Suggested
Barley	0	700	400
Beet pulp	0	600	200
Brewers grain	0	600	200
Citrus pulp	0	600	300
Coconut oil meal	0	500	300
Corn	0	700	400
Cottonseed meal	0	800	400
Corn distillers grains	0	600	300
Corn distillers solubles	0	300	200
Corn gluten feed	0	500	300
Corn and cob meal	0	700	400
Flaked soybean hulls	0	600	200
Ground snapped corn	0	800	400
Hominy feed	0	700	300
Linseed oil meal	0	800	400
Molasses	0	600	200
Wheat	0	600	400
Wheat bran	0	600	400
Common or iodized salt	0	20	20
Trace mineralized salt	0	20	20
Steamed bone meal	0	20	20
Dicalcium phosphate	0	15	15
Ground limestone	20	20	20

SPECIAL NUTRITIONAL CONSIDERATIONS

When minerals are deficient should one fortify the feed or add extra minerals to the fertilizer for the land on which the feed will be raised? Either would be satisfactory but at least in the case of copper deficiency Florida experiments indicated that feed fortification was most feasible[2] If cows that have been given this supplement are pastured the results should be not only immediate relief of the deficiency in the cows but also a long range buildup of mineral reserves in the land This is true because in the case of fortified feed some of the mineral matter is sure to pass through the digestive tract unchanged In fact research in progress at the Florida

Station indicates that this has happened in the case of iron- and copper-deficient pastures that had been grazed heavily for several years

Although the minimum requirements of animals for most nutrients is known, these requirements should be used only as a guide, since requirements vary with conditions For example, calcium-deficiency symptoms have been observed in cattle which had free access to a good quality of steamed bone meal The trouble occurred because they were eating large quantities of sugar beet leaves which contained oxalic acid The oxalic acid precipitated the calcium thus keeping it from being absorbed in adequate amounts

Some peat soils are particularly high in molybdenum, an element which interferes with copper metabolism The recommendations for copper made by American Feed Control officials is 0 3 per cent of the mineral supplement On the mucklands of Florida and other areas such as those around Lake Michigan, however, it is necessary to include as much as 1 25 per cent of copper

It seems possible that tin above the usual levels also may increase the requirement for copper, though more work on this relationship is needed Recommended mineral supplements vary with the type of deficient soil as follows

(1) Mineral soils Common salt 100 pounds, copper sulfate 1 pound, red oxide of iron 25 pounds, cobalt sulfate 1 ounce

(2) Organic soils Common salt 100 pounds, copper sulfate 2 pounds, oxide of iron 10 pounds, cobalt sulfate 2 ounces

In recent years considerable publicity has been given to large increases in milk production that have occurred as a result of increasing the concentrate offering considerably above the requirements shown in Appendix D It is not unusual now for dairymen to feed their best cows as much as 40 pounds of concentrate feeds daily Whether the cows respond to extra concentrates or not depends upon the *ability of the cow* and the *quality of both the roughage and concentrate feeds* Even the best quality hay, silage, or permanent-type pasture grasses apparently must be limited in order to make room for enough concentrates to support maximum production in very good cows

However, the succulent pastures such as clover, alfalfa, millet, and the like, can often supply at least 50 per cent more dry matter than do hay silage or permanent pasture grasses Moreover, the dry matter is about as digestible as is that of the concentrates Thus when these roughages are used as suggested on page 130 so that their high moisture content is not detrimental, the feeding standards are about right for good cows Of course, all dairy cows should be fed liberally enough to determine their *maximum* capability to produce

It appears however that at least 25 per cent of the TDN should come from roughage in order to keep the digestive system functioning properly

As previously indicated the proper balance of nutritionally necessary minerals is essential Thus calcium and phosphorous phosphorous and various trace elements and possibly calcium and the trace elements should be in proper dietary ratios even though the ruminant is more adaptable to various mineral ratios than are other species

Another feature that influences feed requirements is soil characteristics As more calcium is used in soil the pH rises and trace elements such as iron copper and manganese may be precipitated in insoluble forms tending to prevent their absorption Moreover as the pH rises molybdenum may be utilized to a greater extent thus increasing the requirement for copper Hence even when application of lime is a general recommendation it should be accompanied by soil tests otherwise nutritional deficiencies in the animals could be caused by following recommended soil management practices However this seldom happens

Differences in the health of individual animals can result in differences in nutritional requirements For example lack of Vitamin A may cause a weakening of epithelial tissues so that attack from various parasites is more likely Moreover digestive disturbances may be intensified to the point that absorption is difficult and hence requirements may be higher than normal for various nutrients The effects of disease stress will be considered at greater length in Chapter 12

11 SANITATION

Constant attention to sanitation is probably of more importance in the dairy business than in any comparable one. Calves are born with little resistance to disease; if they are not left in clean quarters, as many as 50 per cent are likely to die during the first 60 days following their birth. No other product is more easily contaminated than milk, and no other feed is as important in the diet of children, the infirm, and the aged; moreover, milk is a valuable staple food for healthy adults.

Cattle must be clean and healthy to be profitable (Figure 11-1), since dirty lots, barns, and pastures as well as improperly handled feeding and breeding programs can spread disease. Furthermore, many diseases are transmissible from cattle to man. A good method for barn sanitation is shown in Figure 11-2. In the battle against disease, pest control (largely a matter of sanitation) should be given careful consideration. Personnel who work with cattle must be healthy and must not be disease carriers. In fact, even frequent changes in personnel are undesirable because new people may bring organisms for which immunity has not been established in the herd.

The subject of sanitation is so critical that the fundamentals of cleaning and disinfection deserve special mention.

PRINCIPLES OF SANITATION

The first principle of sanitation is *cleanliness*, and this applied to *all buildings, equipment, animals, land, and people* involved directly with the production of milk. The destroying of disease organisms or the prevention of their growth can be accomplished only if careful cleaning is practiced. Disinfectants which contact unclean surfaces kill few microorganisms, since many of them are imbedded in organic matter and thus escape contact. The value of good cleaning before use of disinfectants was demonstrated in two tests described by Mallman.[2]

The first test involved a concrete wall on which the bacterial count was 28 million per two inches square. Spraying with a good disinfectant reduced the population to 11 million, which was still an immense contamina-

Figure 11-1 Daily grooming is an aid to health and sanitation (Courtesy Babson Brothers Co)

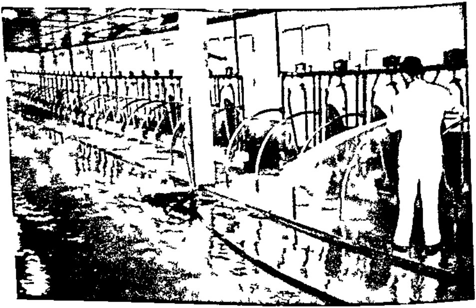

Figure 11 2 Modern barn being cleaned by washing manure into a settling tank from which it will be pumped out to pasture areas

tion However, washing with a good alkaline detergent removed 99 8 per cent of the bacteria Moreover, after the wall was visibly clean, application of the disinfectant reduced the population to less than 100 per 2 inch square

In another test, two milking machines were cleaned and sanitized thoroughly before but not during the test week Each day one was rinsed with an *acceptable* sanitizer and the other with an *effective* sanitizer but neither was washed During the first four days there were few bacteria in either machine, however, as milk soil began to build up and offer the bacteria protection from the sanitizers, a steady increase in bacterial population was noticeable Although the population built up more rapidly with the merely acceptable sanitizer, the effective sanitizer also failed to keep the bacterial count within tolerable limits, thus showing that disinfection of milking equipment requires precleaning

Effective cleaning begins with the removal of waste, followed by scrubbing or other means of obtaining visible cleanliness and by the application of disinfectants

THE CHEMISTRY OF CLEANING

In order to make the best use of available materials the manager will need to consider the functions of the cleaning materials, therefore, these functions will be defined briefly

Definitions

Emulsification Emulsification as it occurs in cleaning is defined as the process whereby fats are broken up into small particles and mixed uniformly into water by the aid of an emulsifying agent Emulsification makes the cleaning of surfaces covered with fatty residues quite easy

Saponification This is a chemical reaction between fats and alkalies which results in soaps Since greasy materials become water soluble, these can be removed after saponification

Wetting Wetting is the action whereby water spreads evenly over the surfaces of soil or equipment Common wetting agents are soaps and detergents

Penetration This is the action by which cleaning liquids enter porous materials Wetting agents cause penetration to occur, in fact, penetration may be considered a special application of wetting

Dispersion of Deflocculation Aggregates of soil particles can be broken up into individual particles by dispersing agents, then they can be washed off the surface to be cleaned

Suspension Suspension is the action of holding insoluble particles in

the liquid media although they are not dissolved In this state they do not form deposits and are readily rinsed away

Peptising Peptising is similar to suspension, but it involves very small particles of materials which may be partially soluble The protein soils are so affected and thus peptising is a very important part of cleaning

Chelating Chelation is the complexing of materials in a way which inactivates them Thus chelating agents used in cleaning inactivate the materials which cause water hardness Moreover since the chelates are soluble, they do not result in insoluble precipitates

Cleaning Materials

The materials used for most cleaning operations may be classified as follows

(1) *Alkalies* The alkalies are very useful in removing fats They consist mainly of lye, sodium carbonate, sodium metasilicate, and sodium bicarbonate

(2) *Phosphates* Trisodium phosphate is an excellent cleaner for most organic residues, and is an ingredient in many dairy cleaners It softens water by precipitation and thus if used in dairy operations it is well for a chelating agent to be included also *Mono* and *disodium phosphates* are useful also, but are not as alkaline as is trisodium phosphate *Sodium tripolyphosphate* is a moderately alkaline material which chelates the hardness out of water It makes other cleaning ingredients more effective and is a good cleaner in its own right *Sodium pyrophosphate* also is a moderately alkaline material which is an effective water conditioner and cleaner

Wetting Agents. Soaps are among the most common wetting agents They are formed by the reaction of fats with alkalies The end of the molecule at which the reaction occurs becomes polar (particularly attractive to and by water) The other end remains chemically similar to the fat from which it was derived and is decidedly nonpolar This opposite chemical tendency of different molecular parts is characteristic of all wetting agents Soaps are not suitable for use in hard water because they are precipitated as insoluble salts of iron, magnesium or calcium These salts have no detergent action and such precipitates may be difficult to remove from the equipment

Various wetting agents which are not affected by hard water have become available They are called synthetic detergents, wetters, or surface-active agents There are three general types of these materials

(1) The *anionic wetting agents* take on a negative charge when ionized They are the most common of the wetting agents, and many of them are the main ingredient in popular household cleaners Although essentially

neutral in reaction, they can be adjusted for use in either acid or basic media Chemically, anionic wetting agents are largely sulfonated alcohols and alkyl sulfonates and sulfates However, thousands of chemical combinations are possible, and numerous anionic wetting agents are in use, one of the most common being sodium laurel sulfate which bears the trade name of Dreft

(2) A large number of useful *nonionic wetting agents* are available Since they do not ionize, they may be employed with either anionic or cationic materials However, they are compatible with most other cleaning and disinfecting materials The nonionic wetting agents are known chemically as ethers, esters, or alcohols A typical nonionic agent is glycerol monostearate

(3) The *cationic agents* possess a positive charge, and are capable of reversing the action of soaps Most of the cationic agents are ammonium salts In general they should not be employed with anionic materials because insoluble precipitates are likely to form On the other hand, the effectiveness of the quaternary ammonium compounds (which are cationic wetters), can be increased by using them in conjunction with nonionic wetting agents [1]

Wetting agents follow definite principles of molecular physics within a solution, the molecules of water are attracted to one another, and they move freely in the interior of the container which holds the solution However, when the solution is applied to a surface in the open air, we find that since air does not attract water molecules they are attracted only from the bottoms of the molecules and laterally Thus a hardening occurs at the interface In the case of the air-water interface this accounts for surface tension *The role of wetting agents is to reduce surface tension and allow the liquid to move over the surface*

Interfacial tension occurs also at any point a liquid contacts other liquids, solids, or gases A good example of high interfacial tension is rain drops which stand up on a well waxed surface of an automobile, for there is little attraction between water and wax Wetting agents are quite useful, since they are adsorbed on the surface where they reduce tension and cause sanitizers to spread rapidly

Acids. The two general types of cleaning acids are organic and inorganic *Organic acids* and their salts help stabilize water minerals, keeping them from forming films or deposits They often are included with wetting agents and alkaline cleaners Organic acids used frequently are acetic, hydroxyacetic, lactic, gluconic, citric, tartaric, or levulinic

Common *inorganic acids* are phosphoric, nitric, sulfamic, hydrochloric, and sulfuric These materials are used for removing residues such as scale, lime, waterstone, and milkstone

WATER REQUIREMENTS

An abundance of clean water is essential to herd health and adequate sanitation Hence the water supply must be reliable In addition, it must have the following qualities

(1) It must be free from organisms which cause disease or spoilage of the products

(2) It must be clear and colorless Suspended particles would make cleaning, cooling, processing or use in boilers difficult and prevent adequate consumption by the cattle

(3) It must be free from odors caused by dissolved organic gases or other undesirable materials

(4) It must be soft, especially for use in boilers and cleaning operations

(5) Iron and magnesium oxides must not be available in quantities which cause staining

If necessary, the water supply can be treated to achieve the above results In fact some treatment usually is necessary This may vary from simply adding a mild bacterial inhibitor to extensive filtration and chemical treatment Much of the water used in dairy operations must be treated chemically to remove iron, calcium, and magnesium salts which cause scale or sulfur compounds which impart undesirable odors

Although drinking cups and troughs are necessary for sound husbandry, they can contaminate the water supply if they have submerged valves This is because vacuum is created and water flows from high to low parts of the system when the water system is used extensively at different planes at the same time The problem *is a simple matter of siphoning* Hence, *all valves for any containers which could be a source of contamination must be above the highest level the water can reach so that contaminated water cannot re enter the valve and be siphoned to a lower part of the water system*

Hot Water

Probably nothing is more important to dairy sanitation than is a *system for heating water* It is essential for washing udders, bulk tanks, pipelines, milking machines, utensils as well as for calf feeding veterinary services, and general use

The proper temperature for the hot water is 160°F If the heater is too small, dilution with cold water may bring the temperature considerably below a satisfactory level when it is most needed The amount of hot water employed will vary of course with different systems and personnel

For purpose of planning however, it appears that a satisfactory daily supply would include the following for each calf, 1 quart, for each udder, 1 gallon bulk tank 3 to 4 gallons per 100 gallons capacity, pipelines, 8 to 10 gallons per 100 feet if washing with pressure, and about 5 gallons if a

vacuum system is employed Few operations can maintain proper sanitary conditions with water heaters of smaller than 100 gallons capacity

Frequently a large part of the water heating can be done electrically during the part of the day when usual demands for electrical service are low Low rate off-peak circuits for jobs which can be done late at night are available in many areas

DISINFECTION

Common Disinfectants

Disinfectants employed in dairy operations are as follows

(1) For general disinfection the virus organisms are controlled best by strict cleanliness Plenty of hot water, water softeners (where needed), wetting agents, and good brushes are required

(2) One of the best cleaning and bacterial disinfecting agents is lye, since it kills and cleans at the same time In fact, in a 2 per cent solution lye is effective against most disease-causing bacteria *Caution is required in using lye because it is very irritating to the skin and quite corrosive to most metals* However, it does no harm to wood and concrete surfaces and has a beneficial effect on rubber

(3) The cresylic compounds are effective against all but the spore-forming organisms Although these materials are good on large surfaces, they are seldom employed for utensils because their action is too slow Moreover, they are likely to impart undesirable odors to the materials cleaned and consequently to the milk Since the cresylic disinfectors per se are only slightly soluble in water, these materials must be emulsified in a mixture of alkali and soap (or other wetting agent) In the form of an emulsion, a cresylic material is quite stable and mixes readily with water

(4) One of the most useful classes of disinfectants is provided by hypochlorites Their fast action makes them practical for utensils These materials are very effective in concentrations of 200 ppm A gallon jug of hypochlorite laundry bleach can be diluted to 250 gallons of 200 ppm solution, the hypochlorites are inexpensive

Sodium hypochlorite is sold in liquid form in concentrations of 3 to 5 per cent The sodium salt is less likely to leave mineral deposits from milk or water (milkstone and waterstone) than the calcium salt The latter is more convenient, however, since it is available as a powder containing 15 to 70 per cent of the disinfectant

Although the hypochlorites are employed frequently to disinfect the udders of cows, they can be irritating to the hands of the workers and to the udders In addition, hypochlorites cause cloths used in the cow-cleaning operation to deteriorate quite fast Moreover, care must be taken to keep the solution clean, since organic matter causes the hypochlorites to

disintegrate rapidly. It should be noted that the hypochlorites are slightly corrosive to tin surfaces.

(5) The quaternary ammonia compounds are not only noncorrosive and nonirritating but also they are affected much less by organic matter than are the hypochlorites. However, they are slower in action. These materials, as the name implies, are derived from ammonia. They are quaternary because the ammonia is substituted in four places by chemicals attached to the nitrogen nucleus. Concentrations of 200 ppm are used for udders and utensils. The quaternaries appear very promising as bactericides, especially those having 12- and 16-carbon alkyd chains.[4] In some cases the quaternaries have been employed in connection with nonionic wetting agents as cleaner-sanitizers.

(6) The iodophores depend on free iodine to kill the organisms, they are quite effective and neither corrosive nor irritating. The iodophores are employed frequently on cattle and utensils but only to a limited extent on large surfaces.

Effect of pH

The acidity or alkalinity of the material to be disinfected determines to some extent what sanitizer to choose. For example, hypochlorites are ineffective in alkaline solutions. Quaternaries usually work better in alkaline than in acid solutions.

A series of tests[4] with a quaternary ammonium disinfectant in acid, neutral, and alkaline solutions showed the following effect on *Micrococcus pyrogenes* var. *aureus*. The kill was 55.6, 96.2, and 100 per cent in solutions of pH 5, 7, and 9, respectively. Thus a complete kill was achieved at pH 9. However, if the length of time of application or the concentration of the disinfectant had been increased materially in the other solutions, a complete kill could have been expected for them as well.

The Hardness of Water

Since mineral matter in the solution may interfere with the efficiency of the disinfecting action, the use of lye for rubber parts always is recommended. In fact, storage of teat cup liners in lye solutions has been advocated recently. However, this is a good procedure only if metallic salts are not precipitated from the water by the lye.

The cresol solutions are less effective in hard than in soft water, because calcium, magnesium, and iron interfere with quaternary ammonium disinfectants.

Effect of Temperature

Any solution is somewhat more effective as a disinfectant when warm because interfacial tension is likely to be lower. Thus cold solutions

should be stronger than warm ones, although lye is almost as effective at low as at high temperatures

Shape of Structure

The disinfectant must touch the microorganism to be efficacious How well this is accomplished is determined in part by the shape of the surface being cleaned Some organisms tend to lodge themselves in structures in which minerals from milk form hardened deposits (milkstone) as shown in Figure 11-3 Surfaces that are round (Figure 11-4) are easier to clean than square corners (Figure 11-5)

Figure 11-3 A good place to look for milkstone

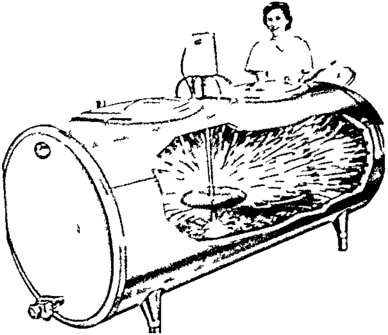

Figure 11-4 Round surfaces and automatic washing equipment insure sanitation (Courtesy Zero Corporation)

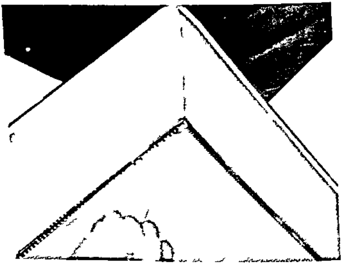

Figure 11-5 Square corners cause serious sanitation problems because they are almost impossible to keep clean

is laborious, and inaccessible areas may be cleaned improperly unless special care is exercised. Excellent results have been obtained with a steam-jenny type of vapor-spray unit in cleaning and disinfecting operations. These machines deliver water at over 100 pounds of pressure. The water delivered to the area to be cleaned is about 212°F. The detergent and disinfectant are applied at the same time.

(3) Use the disinfectant in proper concentration: warm, or hot, if possible.

(4) Apply disinfectants liberally and thoroughly with a spray pump or a brush, depending upon the size of the area.

(5) Allow plenty of time for the disinfectant to act. All residues of the disinfectants should be removed by thorough rinsing before animals are admitted. The following are cheap and effective disinfectants for farm cleaning: (a) solution of Cresol USP, a pint to 2½ to 5 gallons of hot water; (b) lye, one 13-ounce can to 15 gallons of water, or 1 pound to 20 gallons; (c) anionic detergents (Dreft, Swerl, Tide, etc.) 1 pound to 40 gallons of boiling water.

12 HEALTH

EVERY YEAR IN THE UNITED STATES ABOUT 1.5 MILLION CATTLE ARE LOST because of disease. In fact, it is estimated that livestock diseases cost American farmers two billion dollars annually. Most of these losses could have been avoided by applying the principles already presented in this volume. Proper feeding, sanitation, milking procedures, and a daily inspection together with adequate veterinary services are fundamental to profitable dairy production.

Although disease prevention is the primary consideration, control and therapy come to the forefront once disease has been contracted. For these latter measures the services of a practicing veterinary are indispensible. Nevertheless, some useful veterinary assistance can be acquired from other sources. Many suggestions can be obtained from veterinarians in State Agricultural Extension Services, bulletins prepared by dairy companies, textbooks, and the Yearbooks of Agriculture for 1942 and 1956.

In the present chapter, after a brief discussion of general health measures, we will consider the principles involved in the prevention of disease. Then we will proceed to a study of the major diseases affecting dairy cattle before taking up the related subjects of bloat and poisoning.

GENERAL HEALTH MEASURES

Stress

The information in Chapter 1 and other discussions of stress should be kept in mind during the study of the prevention and treatment of animal infirmities. Good management practices for elimination of the deleterious effects of stress include the provision of proper feeds, the prevention of injury, and the keeping of afflicted animals comfortable. *Since the animal depends on its manager for security, special attention should be given to sick animals.* Dairy cattle are sensitive to the attitudes and practices of those who work with them. Use of a blanket, special grooming, and frequent visits make a great deal of difference. In cold climates, a hospital barn (or area which is

enclosed and can be heated) is necessary to prevent stress factors from complicating sickness

Feeding

The Role of Appetite. The appetite of sick cows should be teased by supplying especially palatable feeds but not in amounts that ever satisfy the appetite *All cows should be kept slightly hungry* When a cow leaves grain or eats without apparent relish, her feed should be cut back until she licks the manger Often, serious illness can be averted by observing and catering to the cow's appetite

Medicated Feeds. These are available for all classes of livestock The medicated feeds contain such additives as antibiotics, chemical antimicrobial substances, anthelmintics, and tranquilizers They can be helpful if used *in connection with, but not as a replacement for, careful management and veterinary services*

Cleanliness

An established infection can be aggravated by filthy conditions at a time when the dairy cow is already in a weakened state Therefore careful attention must be given to the sanitation of the stall and to other measures of cleanliness during periods of incapacity, and should be performed with the minimum of activity in order to avoid unnecessary stress

Inability to Rise

Occasionally a cow will be found lying down and unable to get up because of (1) injuries from a fight or fall, (2) paralysis from injury during the birth of her calf—this happens when the calf is very large or abnormally positioned so that birth causes a broken pelvis and/or a nerve injury, (3) intoxication due to fermented or toxic feeds, (4) the after effects of difficult calving that has sapped the adaptive energy, (5) weakness stemming from heavy production, nutritional deficiencies, or old age, and (6) tumors or other diseases that affect the brain or spinal column

The hip sling can be utilized to pick up disabled cows They should be moved to the most comfortable location available and treated according to their individual needs

* * *

Before discussing important diseases and their prevention and treatment, we will first consider the general principles underlying prevention of disease, since effective prevention is fundamental to the maintenance of health

PREVENTION OF DISEASE

The prevention of disease involves the following factors environmental control, immunization, veterinary help, medical supplies, and disinfection

Environmental Control

Most hardware diseases and accidents can be avoided by merely keeping equipment in good repair. This means prompt replacement of lighting and plumbing fixtures, immediate repair of broken fences, careful and regular cleaning and oiling of equipment, as well as the adequate cleaning of housing facilities. All worn out parts should be replaced without delay.

Much mastitis can be prevented by proper care of the milking equipment. The chief malfunctions of the milking equipment are manifested by slow milking, uneven milking, or irritated teats as we have previously indicated in Chapter 6. The causes of these conditions and the measures for correcting them should be known and applied (see page 60).

For the prevention of corrosion, the adding of sodium silicate to water systems is quite effective, the silicate film deposited on the metal surface is not harmful to the body. Painting should be done as needed to protect against erosion and decay. These measures are desirable supplements to general principles of cleaning and sanitation.

The junk pile on the farm should be inaccessible to cattle, and dangerous obstructions should be removed from their path, particularly when conditions are crowded and lighting is inadequate.

Disease can be introduced on the premises by newly purchased stock or by cattle returning from fairs and shows. Hence all cattle brought onto the farm must be isolated for 30 to 60 days. If cattle are kept on adjoining property, double fences to prevent contact are worthwhile.

Infection can be carried also by visitors, by streams, stray animals, birds, flies, insects, and rodents. Thus constant attention is required (Figure 12-1). Visitors should not be allowed to walk in feed alleys, feed rooms, or feeding areas. If possible, feed should be purchased as bulk, or in bags not used previously for livestock feeds. Bedding or feeds should never be carried in trucks that have hauled animals.

Immunization

Immunity refers to the ability of an organism to resist disease from infectious microorganisms or their products. Immunizing agents are available for the counteraction of anthrax, blackleg, malignant edema, hemorrhagic septicemia, brucellosis, some types of mastitis, leptospirosis, red water disease, and tetanus. Not all types of immunization are necessary in all herds, and deciding which to use is part of the veterinarian's job. Frequent tests should be made for mastitis, tuberculosis, and brucellosis, because of the seriousness and prevalence of these diseases among dairy cattle. The proper immunizing agent to be employed can be determined by the veterinarian.

Cattle should be vaccinated at regular intervals as needed, with care being taken that the animals are free of disease and parasite infestation

Figure 12-1. Dusting cows with a fly repellant is accomplished easily without noise or other disturbances by use of a feed bag.

prior to vaccination Nevertheless, although vaccination is a good tool, it will not replace good all-around husbandry, for some animals respond differently to vaccination than do others Whether animals are healthy, well-fed, and properly managed has a direct bearing on how well they build protection after vaccination

A frequent professional review is desirable because advances are being made rapidly in effectiveness of the various immunizing agents Thus longer-lasting, safer, more dependable vaccines are being developed, and only the best should be used because the same time and labor are required as with the outdated materials

Medical Supplies

The herd manager also needs help in deciding what medicines and supplies to keep on hand Many minor diseases and most immunizations can be handled by a competent herdsman who has adequate medical advice Generally, the dairy veterinary cabinet will contain the following clinical thermometer, drenching bottle, milk-fever injection set, trocar and cannula, hypodermic syringe, mineral oil, epsom salts iodine carbolated vaseline, and calcium gluconate with added soluble carbohydrates

A refrigerator will protect most immunizing agents and many drugs from rapid deterioration Facilities for cleaning and sanitizing equipment must

be nearby and space must be available for special drugs that may be required by the veterinarian

Sanitation and Disinfection

Sanitation and disinfection have already been discussed at length in Chapter 11 However so important are these factors in maintaining health that their particular relevance to the prevention of disease will be given special attention here

Certainly sanitation and disinfection are essential in all cases and the freeing of the environment of causative agents is a fundamental measure in all disease control Since cleanliness and sunlight are material enemies of disease buildings must be kept dry light well ventilated and clean and lots should be drained and kept clean In addition racks and bunkers are necessary since feed on the ground is likely to result in inadequate sanitation

Flies and insects should be prevented from breeding wherever possible by keeping manure deposits of decaying vegetable matter and stagnant water at a minimum For those which do hatch control with insecticides baits and traps usually is effective

Droppings on pastures should be scattered after each rotation Mud holes swamps and stagnant pools should be eliminated since they harbor and help spread many diseases

Care in dealing with infected animals and in cleaning quarters or disposing of dead animals cannot be overemphasized In addition to economic factors human health is involved over 80 diseases (some of which are deadly) are known to be transmitted from livestock to man

Disinfection must be practiced on all pens lots and barns The procedures recommended on pages 154 155 will tend to increase the effectiveness of disinfection

In addition the following are recommended for preparing the skin for injection and for treating skin wounds

(1) A 2 per cent solution of Compound Solution Cresol USP (5 teaspoonfuls to a quart of water) is an ideal cleansing and antiseptic agent for treating an area in which injection is to be made
(2) Tincture of iodine is the standard antiseptic for skin treatment of superficial wounds

Thorough and regular inspection of each animal in the herd is the manager s responsibility Most epidemics are thus prevented and minor health problems are not allowed to grow

MASTITIS

No discussion of dairy cattle health would be complete without special mention of mastitis This udder malfunction costs American dairymen a quarter of a billion dollars annually Yet it is not necessarily a complex disease The Greek word "mastos" refers to the mammary gland, the medical suffix "itis" means inflammation Thus inflammation of the udder from any cause is denoted mastitis (Figure 12-2)

Moreover, mastitis may be caused by *any* type of bacteria or other microorganisms capable of *irritating* injured tissues In fact, in most cases the disease follows injury to the udder tissues, the majority of which occur during milking Some udders are especially vulnerable to mastitis (Figure 12-3)

Perhaps the strip cup provides the easiest way to check for signs of mastitis (Figure 12-4) The strip cup may be partially covered with black wire mesh (100 squares per inch) and/or a glazed black metal surface As soon as the milk is let down a stream is directed onto the examination surfaces The presence of flakes, clots, or off-colored milk is indicative of mastitis Moreover, the first stream of milk from each teat is likely to be high in bacterial content and employment of the strip cup gets rid of this Concurrently, the milker can determine whether let-down of milk is complete The stimulation of the pituitary gland to release oxytocin (which accompanies utilization of the strip cup) is in itself a valuable aid to full let-down

Mastitis can result in permanent injury because scar tissues replace secretory tissues Even when mastitis is detected and treated in an early stage, the loss of milk production, time, and drugs, as well as the permanent damage of milking tissues amounts to a considerable value

Prevention

The milking machine is perfectly safe when used properly because the milk acts as a lubricant between the tissues However, its vacuum is quite strong, and *rough handling during milking accounts for much mastitis* Thus if the machine is applied before milk is let down or is left on after the milk flow stops, the streak canal and teat cistern are likely to collapse because the insides of these delicate structures would be rubbed together at each pulsation Moreover, under these conditions the teat cups are likely to creep upward, pinching or bruising the gland cistern (Figure 12-5) The same type of irritation can occur if the teat-cup liners are worn or dirty or if the pulsation rate and vacuum are improperly adjusted

Furthermore, since the udder can be bruised by the cow herself if she is hurried to and from pastures, the person responsible for moving cows

Figure 12-2 Mastitis of dairy cows in the United States is experienced by one dairy cow out of four (Courtesy Chas Pfizer & Co, Inc)

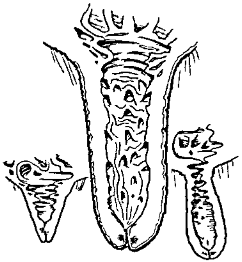

Figure 12-3 Deformed teats predispose the cow to mastitis At the left is a teat with abnormal streak canal and cistern, the center drawing shows a pocketed teat which could hold bacterial infected milk, abnormal growth of annular rings obstruct passage between udder and teat cisterns in teat shown at the right (Courtesy Babson Brothers Co)

Figure 12-4 Use of the strip cup shows up abnormal milk before milking, providing a safeguard of the milk supply and a warning of mastitis (Courtesy Babson Brothers Co)

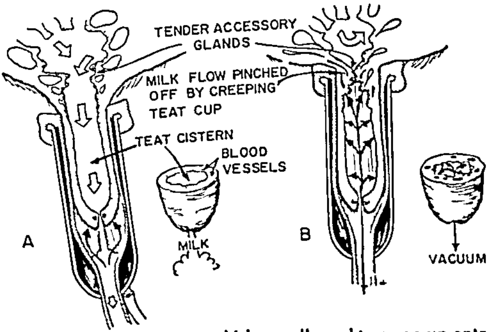

Figure 12-5. Teat cups which are allowed to creep up onto the udder can cause serious damage (Courtesy Babson Brothers Co)

should walk behind them The use of dogs, horses, and motor vehicles for driving cattle is a common cause of mastitis

Although not mentioned often improper procedure in removing teat cups is a very serious error If the teat cups are pulled off with vacuum still applied, delicate tissues in the udder are drawn together sharply, frequently with enough force to cause severe injury leading to mastitis The proper way to remove teat cups is to break the vacuum by pressing the teat in just above the cup When this is done, the teat cups fall away from the udder

Treatment

Dangers of Antibiotics Although the right medicament will cure specific cases of mastitis over reliance on drugs is a serious threat At this writing, antibiotics for udder infusion, available readily for over 15 years, have been administered indiscriminately *Anyone* can employ almost *any* combination of antibiotics to treat *any* mastitis However, no one drug kills all of the causative agents and recurrence of mastitis after its cure is almost certain because the source of the microorganisms involved in mastitis is likely to be contacted routinely by all cows

More than 75 tons of drugs are used annually in the United States alone for the treatment of mastitis Yet the incidence of the disease has not de creased in the last 15 years When penicillin first became available for veterinary use 100 000 units was a therapeutic dose then 200,000 and so on until some mastitis treatments consisted of as much as 800,000 units of penicillin and as many as four additional drugs

Excessive reliance on antibiotics has had very unfortunate consequences (1) Old standby methods of mastitis prevention have been relaxed, (2) anti biotic resistant organisms have developed and (3) considerable market milk has been contaminated with drugs

Surveys by the Pure Food and Drug Administration have shown that as much as 10 per cent of the milk sold during some periods contained anti biotics This contributed such a threat to human health that a zero toler ance has been established for antibiotics in milk Thus antibiotic treatment should be limited to cases actually requiring this type of therapy No milk can be used for at least 72 hours after udder infusion or general systemic treatment with antibiotics

Recommended Procedures Mastitis is essentially a man made problem The best solution at present is careful management for the prevention of injuries and the detection of udder abnormalities in the early stages Over all treatment involves following recommended procedures of sanitation testing and medication

Sanitation New sanitizers on the market for cleaning machines and

udders are better than previous ones, which owing to the importance of sanitation is a most encouraging sign

Since most of the microorganisms on teat-cup liners seem to come from the skin of the teats, the udder should be washed carefully prior to milking Iodophores and chlorhexidine are the best available disinfectants Machines should be rinsed in plain clean water, then in a clean sanitizing solution before being attached to each udder If solutions are not changed frequently, bacteria will build up in them Thus after washing and dipping solutions have been employed on a dozen or more cows, further utilization of them often amounts to bathing the openings of the teats and dipping the machines into suspensions of potential pathogens

Immediately after milking, cloths employed on the udders should be washed carefully and placed in a good disinfectant such as a solution of quaternary ammonium compounds, iodophores, or chlorhexidine If the strip cup shows that a cow has abnormal milk, she should be milked by hand, or at least special care should be taken to completely sanitize any equipment used on her udder

Some dairy managers suggest dipping the teats in a sanitizing solution after the completion of milking This practice has several disadvantages, however If the cows are turned out with the teats wet during cold weather, chapping is likely to occur, particularly if a hypochlorite solution has been employed Moreover, the causative organisms are apt to be contacted after the disinfectant is gone For the most part, attempts to seal the openings to teats have been unsatisfactory because of dirt contacting and bonding to the teat by the sealing material (usually collodian) An ideal solution for after-milking teat treatment should contain an effective disinfectant and a sealant, the solution should dry very rapidly Various solutions of this type are now in development

The environment of lactating cows needs constant attention Dirty lots, inadequate housing, crowded or cluttered holding and feeding areas, or anything else which is a potential source of injury or infection, must be minimized

Testing A logical follow up for suspicious udders is the California Mastitis Test (CMT) or the Michigan Mastitis Test (MMT) The equipment for these tests is shown in Figure 12-6 They are simple tests which any dairyman can run by the utilization of a reagent that coagulates and colors abnormal milk Part of the reagent causes mastitis milk to coagulate (this is an anionic wetting agent in concentration of 3 to 5 per cent) and another part is a dye (Brome Cresol green) in the CMT, and methylene blue chloride in the MMT A change in color shows alkalinity—another sign of mastitis The MMT is the newer of the tests and requires less expensive reagents

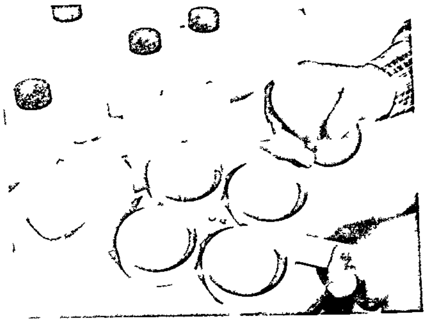

Figure 12 6 The California Mastitis Test (CMT) is used to determine the degree of inflammation A chart of results should be kept to plot progress in eliminating mastitis (Courtesy Deere & Co)

However, both tests are similar in almost all respects and are for the same purpose *They indicate the degree of mastitis by measuring the products of inflammation in milk as it comes from the udders* Large quantities of leucocytes are present in inflamed udders they are high in proteins which react with the CMT or MMT reagents to form a gel The degree of gelling is related closely to the number of leucocytes present Although these tests do not necessarily show that an animal is infected cows which show positive reactions are at least predisposed to the disease

Medication Often bathing inflamed udders with hot oil solutions causes mild abnormalities to clear up quickly When more drastic medication is indicated it should be directed by the veterinarian He must examine the milk to determine the identity of the causative organisms, then he can prescribe medication

Udder infusion may be employed but in most cases this technique is of doubtful merit The nature of the mammary tissue makes it difficult for infused material to reach the affected areas Moreover keeping infusion equipment sterile is a serious problem thus use of this technique may actually induce additional infection Systemic injections are more practical even though the infection is local

Staphylococcus aureus One of the fastest gaining types of mastitis appears to be that caused by *Staphylococcus aureus* because it cannot be controlled as

readily by antibiotics as most other types can It has been found that vaccination with staphylococcal toxoid or bacterin-toxoid stimulates production of antibodies against staphylococcal mastitis The effect appears to be mainly one of prevention Staphylococcal udder infections are very difficult to cure, and it is estimated that from 10 to 60 per cent of the present dairy cow population is so infected

DISEASES DIRECTLY AFFECTING REPRODUCTION

You will recall that in Chapter 1 we pointed out that the reproductive impulse was the most important thing to promote Although mastitis, because of its serious effect on lactation (a *side effect* of reproduction), is of great concern to the manager, those diseases which have a *direct* effect on reproduction also cause tremendous losses Such diseases as trichomoniasis, vibriosis, leptospirosis, and various types of vaginitis and nonspecific infections are spread by either artificial or natural breeding Thus special precautions should be taken in examining any bull for either type of service

Trichomoniasis definitely is a venereal disease caused by the organism *Trichomonas fetus* The symptoms to look for in dairy cows are early abortions and pyometritis The uterus of infected cows may be greatly swollen and filled with pus Such animals are listless and often have abnormally high temperatures An infected bull is almost impossible to cure The infection is likely to be in the testes, and thus it is difficult to treat systemically and impossible to treat by local application of medicaments A hygienic breeding program and early diagnosis and treatment of the disease in females with appropriate antibiotics is the only present recommendation Routine use of antibiotics in semen helps control this kind of disease when artificial insemination is used

Vibriosis, vaginitis, and brucellosis also may be considered venereal diseases, since they affect mainly the system of reproduction Leptospirosis may involve the reproductive system and/or other parts of the body *All of these diseases may be spread during breeding as well as in other ways* Urine (particularly in the case of leptospirosis) is infective, thus contaminated feed, bedding, buildings, etc , are possible sources of infection Moreover, some animals not showing symptoms can be carriers of disease

Vibriosis is spread by breeding and by other channels Symptoms of vibriosis are as follows abortions in 10 per cent or more of the herd, difficult breeding, still births, weak calves, and vaginal discharges After several months females usually develop immunity, although bulls may be carriers for years Effective control ordinarily involves three months of sexual rest, antibiotics as injections in cows, preputial douches in bulls, semen treatment, and rigid general sanitation

Vaginitis often appears to be the cause of difficult conception It can be spread by the bull or may follow injury at breeding or calving Vaginitis

may result in septic metritis and sterility if the inflammation spreads to the area of the cervix However, granular vaginitis may be disseminated by means other than the breeding process

Brucellosis continues to be a problem although the incidence of this disease is declining steadily The milk ring test is employed to detect suspected animals, and the diagnosis is confirmed by a blood test Calves are vaccinated with strain 19 vaccine when they are 5 to 8 months old This does not immunize the animal completely, but reduces its chances of contracting the disease Once an animal has brucellosis the only safe practice is *to remove it from the herd immediately*

Leptospirosis causes abortions without warning This disease will infect animals of all ages and many cattle apparently are carriers Vaccination with antiserum containing killed organisms, along with treatments and careful management, usually controls leptospirosis

COMMON METABOLIC DISORDERS

No doubt many metabolic malfunctions occur in hard working cows, and most of them result in ketosis (acetonemia) *or in milk fever* Depletion of adaptive energy and the GAS no doubt are involved in both malfunctions Usually the symptoms of these two conditions are similar, nervousness, paralysis, *inability to rise*, or loss of consciousness (see Figure 12-7) Acetonemia may occur in various degrees, slight disturbances may not be noticed

Figure 12-7. A cow suffering from ketosis Milk fever victims assume similar positions

Even these cases are important, however, because they can affect production throughout a whole lactation.

Ketosis

Loss of production is the main consequence of *ketosis;* less than 5 per cent of reported cases have been fatal. The condition occurs most often in high producers. Generally the incidence of ketosis seems to have increased since it was first reported in 1929, and it commonly occurs 14 to 28 days after the cow freshens. Cases have been reported as early as seven and as late as 70 days after calving, however, and the possibility of disorder always is present.

Ketosis is caused by ketone bodies. They are formed for the most part in the liver as an end product of rapid mobilization of reserve nutrients. The demands of production are so strong that feed is inadequate (Figure 12-8),

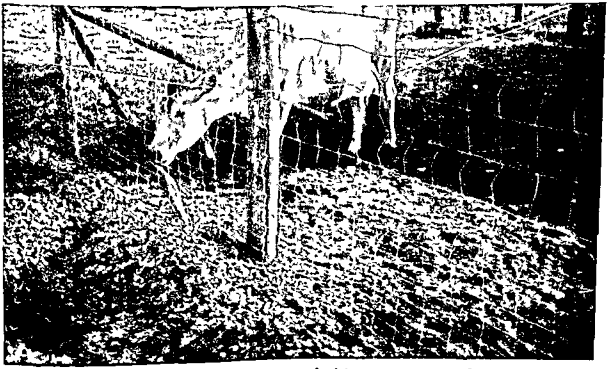

Figure 12-8. Inadequate feed caused this cow to eat fence posts and dirt in quest of missing nutrients.

and reserves are mobilized faster than the by-product, ketone bodies, can be dissipated.

Although stress conditions such as disease, nutritional inadequacy, or other complicating factors must be eliminated if any ketosis treatment is to be adequate, many treatments have been proposed, and most of them help. Glucose or fructose injections are among the most valuable However, since fructose doesn't depend on the action of insulin, it is usually considered superior.

Various drugs related to the hormone corticosterone are used in severe cases of ketosis and they often cause the blood sugar to rise to normal or above within 24 to 48 hours Several days ordinarily are required for the ketone bodies to return to normal but appetite and general appearance improve quickly as a result of the hormone treatment Sodium propionate or propylene glycol drenches are effective in many cases Frequently cattle affected by ketosis can be helped by increasing the feed allowance This is done best by allowing extra bulky concentrates like snapped corn or citrus pulp

Milk Fever

The other common metabolic derangement is milk fever It really isn't a fever in many affected cows body temperature is subnormal Most cases occur within 72 hours after calving It is caused by the inability of the animal s body to mobilize reserve mineral matter (mainly calcium) fast enough to meet the demands of milk production

Milk fever is not caused by a nutritional deficiency and feeding calcium heavily during the dry period doesn t help In fact cows on low calcium diets may be better prepared to mobilize reserves since their respective parathyroid glands and associated systems have been active all along On the other hand, these systems may be out of condition in cows fed excessive minerals before calving Vitamin D in excess of usual requirements fed for five days before calving frequently helps prevent milk fever by mobilizing reserve mineral matter

The preferred method of treatment is injection of a 20 per cent solution of calcium gluconate The symptoms of milk fever are almost the same as those of ketosis and both conditions may be present at once, so most commercial therapeutic calcium solutions also contain sugar Since phosphorous and magnesium may be needed in the treatment they should be included also

When the afflicted cows are nervous or perhaps having difficulty walking but can stand and remain conscious it is best to give the injection into the peritoneal cavity This is done on the right side at the triangle formed by the last rib back bone and hip bone However the solution should be warmed before the injection

If the cow is in a coma she should be kept from lying on her side the injection is given very slowly into the jugular vein In most cases recovery is very rapid

These diseases may occur partly as the result of improper feeding prior to freshening Although the dry dairy cow should have a fitting ration which will enable her to build reserves fattening her like feed lot animals is a mistake She should be conditioned to be strong—not fat Plenty of

impossible for the cow to belch and excess gas accumulates. This type of bloat can be controlled by anti-foaming agents.

Prevention of Bloat

Anti-foaming Agents. Almost any kind of nontoxic oil can be employed to break foam or prevent foaming. In New Zealand pastures were sprayed with peanut oil (3 ounces per head daily) and frothy bloat was eliminated. However, to achieve this, oil must be applied the same day the forage is eaten. Moreover, since rain eliminates the oil, it is almost essential that strip grazing be utilized with the spraying of pastures. Portable electric fences are used to expose just the treated areas to the grazing animals.

At the Iowa Agricultural Experiment Station good results have been obtained with cattle fed from wagons on feed sprinkled with crude soybean oil. Although the oil is toxic to very young calves, it is in no way harmful to animals large enough to graze. A quarter of a pound of oil is sprinkled onto each 75 to 100 pounds of forage before unloading or feeding from the wagons. However, the same job can be done with lard oil, commercial yellow grease, bleached tallow, and various vegetable oils (including the popular cooking and salad oils). Thus it is easy to control frothy bloat in animals fed from bunkers or self-feeding wagons, whether the feed is greenchop, silage, or hay.

If cattle are to be pastured in large areas, frothy bloat probably can be prevented by the utilization of a roughage mixture containing citrus pulp, various other bulky feeds, and a liberal amount of oil. For best results this mixture probably should be fed right in the pasture in the same kind of feed bunks employed for greenchop or silage. When oil is added to the regular barn concentrates, at least a pound of oil per head daily is necessary to prevent frothy bloat. With pasture-fed pulp mixtures, the oil content probably can be reduced considerably.

Water-dispersable oils can be added to drinking water. However, this does not seem to be a practical technique, since at this time there is no way to estimate accurately either when or how much water bloat-prone individuals will drink.

Although various substances other than oils can serve as anti-foaming agents, these materials (waxes, detergents, synthetic surface-active agents, silicones, and alcohols) usually are more expensive, harder to get, and less palatable than oils. Edible oils are available almost universally. Probably there are natural feedstuffs which contain foam depressants. Linseed meal, for example, contains mucin, and this feedstuff appears to reduce the incidence of pasture bloating. Perhaps some types of feed-lot bloat can be alleviated in part by linseed meal or other feeds that control frothing

Research into the effect of various concentrate feeds on the incidence of bloat has not been extensive

Thus each feeder may have to try various combinations Breaking plant cells so as to allow the cell contents to enter rumen solutions as forage is consumed may help prevent frothy bloat caused by some forages The plant cells are ruptured to some extent by hay conditioners and perhaps by some types of forage harvesters Dewatering the forage also may remove bloat-producing substances, or concentrate natural foam preventatives Saliva helps prevent foam Hence supplementary feeds which have to be chewed extensively often help by stimulating salivation

Antibiotics. These drugs sometimes help to prevent the occurrence of bloat When antibiotics are employed in this way, the action is confined largely to the rumen Thus they are not considered harmful in the way that indiscriminate antibiotic dosing is in the case of mastitis In fact, the Food and Drug Administration in November of 1957 approved the use of chlortetracycline (an antibiotic affecting a wide spectrum of organisms) for continuous feeding to dairy cattle The approval was based on the premise that at a level of 0 1 milligram per pound of body weight daily none of the antibiotic appears in the milk Moreover, continuous low-level supplementation appears to help prevent such diseases as foot rot, pneumonia, and shipping fever

Antibiotics often are given with other feeds or by capsules containing 75 to 100 milligrams daily before pasturing (Figure 12-9) Combinations of antibiotics seem to be desirable, as many as five have been used in experimental mixtures with favorable results They may be mixed with the salt which is fed in mineral boxes in the pasture This requires less labor, but some researchers doubt the value of the practice because consumption is likely to be variable and the animals which need medication most may not get it Another objection is that exposure to moisture, including saliva, is likely to cause rapid deterioration of antibiotics Generally, the antibiotics do help but their effect is likely to wear off after ten days to two weeks

Treatment of Bloat

It seems that most pasture and feed-lot bloat can be prevented but what should be done for a cow which is already bloated?

If the bloat is caused by froth, an effective dose of oil can be given by mouth Drenching must be done with care because when the cow is bloated there is an increased danger that the drench will go into the lungs Perhaps it's best to use a stomach tube which is forced into the rumen

To insert the tube, pull the tongue to one side and push the tube right down the middle of the esophagus It may go into the trachea instead, so if

Figure 12-9 Giving medication with a balling gun

the animal coughs pull the tube right back out In any event insert the tube only six inches to a foot at first If it has gone down the wrong way, one can hear the cow breathing through it Usually a tube will slide down the esophagus into the rumino reticular cavity very easily Then about a pint of edible oil can be poured into the rumen In most cases of pasture bloat this brings almost immediate relief In an emergency, a piece of garden hose can be utilized Turpentine or kerosene (about ½ cup) generally will relieve frothy bloat but undesirable side effects occur, often causing digestive disturbances

If medication doesn t help walking the animal or causing her to stand with her front feet higher than the rear feet sometimes helps A smooth stick placed into the mouth as a bit may cause belching to begin

In many cases it may be necessary to puncture the rumen This seems drastic but if the other remedies don t bring relief the operation should not be delayed A fully bloated cow may have but a few minutes to live unless the gas is allowed to escape To remove the gas by puncture make a hole in the left side within the triangle formed by the last rib the back bone and the hip bone This should be done with a trocar and cannula but many cows have been saved by quick action with a pocket knife

It also is possible to inject oils or other foam breakers into the rumen at this triangle This is done easily with a gravity set designed for injecting calcium solutions for milk fever One must be sure however that the

needle actually has entered the rumen If oil should be injected into the body cavity rather than the stomach, serious complications could occur

Obviously present knowledge of bloat is sketchy Tremendous effort is being expended by researchers throughout the world, however, and before many years, this centuries-old problem is likely to be solved In the mean time, certain management practices are helpful

(1) Be alert Even though one has never seen a case of bloat, the whole herd could be affected at any time
(2) Keep cattle in good flesh but not fat Most fatal bloat occurs in cows which are either underfed or in those which are too fat
(3) Mixtures of grasses and legumes are less likely than legumes alone to cause bloat
(4) Hay or a good bulky concentrate mixture fed in the pasture may help prevent frothy bloat
(5) In case of feed-lot bloat, coarse feed has been observed to stimulate belching
(6) Immature forage is more likely to cause bloat than is older forage
(7) Before cattle are turned onto pasture, a good fill of hay may prevent bloat by diluting the green forage

POISONING

Now more than ever before there is grave danger of accidental poisoning of livestock Wider use of products which could be toxic is responsible for this danger In this section we will discuss the various causes of poisoning and the measures required for the prevention of poisoning In addition, a brief explanation of how to provide treatment of a poisoned animal is included

Prevention

Poisoning can occur from a wide range of sources such as some forms of herbage, paints, grease on equipment, pesticides, minerals, and even the tars in clay pigeons

Paint Paint is a killer because often it contains lead or other poisonous metals Toxic metals used in paints generally are cumulative poisons, therefore, their effects may not be seen until occasional small amounts build up, as they do, to a lethal dose Moreover, since doses of lead which are sublethal to cows have been shown to cause their calves to be born with deformed legs and spines, it appears that lead poisoning may be one of the factors in crooked calf disease

Cattle will pick up paint which is spilled, and sometimes they lick freshly painted buildings and equipment They are almost sure to get whatever paint they can from used containers, brushes or sticks employed for stir-

ring However, danger from this source is preventable In the first place, special nontoxic paints are available for utilization on stanchions, calf pens mineral boxes or other equipment which animals frequently contact

For outsides of barns and allied structures only two precautions are necessary (1) keep animals away until fresh paint dries and (2) dispose of all cans and equipment so livestock will not have access to them

Machinery and Equipment Farm animals are curious creatures Often they nose around and lick machinery left in pastures, this sometimes leads to ingestion of grease and other lubricants These may cause harm directly, as in the case of skin troubles from chlorinated naphthalene additives Also molybdenum (which may interfere with mineral metabolism) is added to some lubricants in amounts which could be toxic Moreover, lead poisoning has occurred in cattle when they have licked discarded batteries and metallic lead in other forms

Skeet shooting provides good gun safety training for children and it's fine recreation for anyone But clay targets are poisonous to livestock Many animals (pigs especially but cattle also) like to pick up clay pigeon fragments in target sites A number of animals have died from poisoning by the tars contained in these clay targets

Misuse of Medicaments Many modern medicines and other chemicals are dangerous unless employed exactly as directed by the manufacturer or the prescribing veterinarian This applies to materials used for skin troubles and to some medicines for external parasites

Not only must these medicaments be administered in correct doses, they must also be utilized only for the particular class of animals for which they are prescribed A substance which can be safely applied to the skin of a cow possibly would because of its concentration kill a household pet or even a calf

Pesticides Although pesticides for pastures are dangerous if not administered exactly as directed these substances are extremely useful And they are safe—if animals are kept off treated areas and/or mechanical harvest is delayed for the length of time indicated by the label on each poison container

Old pesticide containers must be buried, otherwise some of these may be eaten outright Cattle seem to like the taste of arsenic compounds and some other pesticides which could cause them serious trouble

Weed killers can be deadly to livestock Arsenicals are among the most dangerous of these Cattle seldom eat plants treated with arsenicals but they will drink water containing the poison and hence great care must be exercised in its application in or near pasture areas

Sodium chlorate is palatable to cattle and usually it kills quickly Sodium trichloroacetate (TCA) causes irritation to all tissues However, some other weed killers such as 2 4 D 2 4 5 T and MCP are not toxic

Fertilizers. These can kill livestock also Cattle relish nitrates especially, and will consume lethal doses of this type of fertilizer when it is available to them Therefore, fertilizer must be stored where cattle cannot get to it Moreover, after each fertilization, it is a good idea to keep all stock off the pastures until it rains Even then, for a few days following heavy nitrogen application, pasture grasses (as the only forage) could contain enough nitrate to be dangerous This seems to apply especially to oats Old fertilizer bags should be buried or burned as soon as is practical after they are emptied

Poisonous Plants. Some pasture plants may become toxic when they mature If the seed heads of Dallas, Bahia, or similar grasses look moldy, they could contain ergot This substance causes abortion, and sometimes death Corn stalks may become toxic when they age for long periods during unfavorable weather

Sorghums Other forages to watch are the sorghums As long as these plants (which include Sudan and Johnson grass, Sart Sargo, and some other canes) are healthy, rapidly growing plants, they are not dangerous in any way However, if drought, frost, floods, trampling, or anything else stunts them, prussic acid (a deadly poison) is formed

After the sorghums are cut, sprouts are likely to come out of the stubble These sprouts are high in prussic acid and should not be grazed until they have grown for several weeks If the growing conditions are favorable, cattle have access to plenty of other feed, and nitrogen fertilization is moderate, then there is not likely to be danger from grazing But there could be Second growth sorghum must be grazed only with extreme caution Since prussic acid poisoning causes almost instant death, animals cannot be saved by removing the feed when they begin to get sick

Ensilage made from these plants, on the other hand, is safe unless it is self-fed or very large amounts are taken from the silo at one time and fed immediately This is because the prussic acid is volatile and will evaporate from the surface If large feedings are to be removed at one time, the silage should be spread out for about four hours before cattle are allowed to eat it

Sweet Clover Since the popularity of this plant is growing (especially for greenchopping), some herdsmen are concerned about sweet clover disease However, there should be no reason to worry, for this disease is caused only by spoiled forage Dicumerol, a substance which prevents action of Vitamin K, is formed when mold grows in sweet clover Although dicumerol may be present in other hays to a smaller extent, toxic levels are generally found *only* in *moldy* sweet clover Uncontaminated sweet clover is excellent feed

Systems of Forage Utilization. The way that forage is utilized has a bearing on the danger from weed poisoning Frequently poisonous weeds —including night shade, some varieties of the coffee weed, lupines, and

crotalarias—are found in open pastures Generally with plenty of other feed available not enough of these weeds are eaten by grazing cattle to be harmful since the poisons are well diluted

In strip grazing or greenchopping however almost complete consumption occurs and death from poison weeds becomes more likely Prevention is effected by frequent examinations clipping and (when necessary) spraying with the proper herbicide for the pasture concerned

Even in large pasture areas there is some danger from poison weeds unless the desired type of forage is in generous supply In addition to noxious plants already mentioned cattle have suffered from eating sorrels and docks which contain oxalic acid and from consuming the vegetation of wild cherry trees containing poison glucosides

Improper Use of Nutrients Some essential nutrients are toxic when administered improperly All animals need salt and cattle can eat as much as a pound daily without harm However if livestock have been deprived of salt for long periods they may consume lethal doses when given free access This occurs most often in pigs and chickens but cattle also have died from poisoning by common salt

Occasionally salt is mixed with protein supplements to limit intake of the latter by range cattle or dry dairy cows and heifers Although this causes consumption of considerably more salt than is needed no danger occurs if feeding is done close to a reliable source of water

Supplementary mineral mixtures containing iron copper and cobalt are necessary for livestock in some areas Peat soils are likely to be very high in molybdenum which interferes with copper metabolism Hence copper requirements for cattle grazing on this type of land are apt to be very high A special high copper mixture therefore is recommended for these areas

If cattle consistently maintained on mineral soils consume this special mixture for long periods they can become ill or die from copper poisoning (Copper resembles lead in that it can build up slowly to a toxic level in the body) On the other hand if cattle on peat soils do not receive the special mixtures they may suffer from molybdenum poisoning

Selenium This chemical is concentrated enough in some soils in western United States Canada and Mexico to make plants raised there toxic Certain native plants have been found to grow only on seleniferous soils and can be used as indicators Included are 24 species of *Astragalus* (vetch with pea like flowers) most species of *Xylorrhiza* (wood aster) *Oonopsis* (golden weed) and *Stanleya* (prince s plume) Sulfates appear to alleviate the effects of selenium somewhat whereas they promote the molybdenum copper antagonism Hence the form in which supplements are added can be important

13 REPRODUCTION

THE DAIRY MANAGER IN A BROAD SENSE IS CONCERNED MAINLY WITH reproduction, since milk is produced to feed the young and its secretion is denoted properly as a part of the reproductive function

The effect of reproductive performance on lifetime productivity can be determined by comparing the average amount of milk produced each day including dry periods from the second birthday to the date of last milking Data from two cows raised at the Florida Station can be used to illustrate this principle, as shown in Table 13-1

The lactation average of cow two, 9568 pounds, appears to be superior to that of number one, 7917 pounds Yet the average daily production of cow one was 27 4 compared to 19 3 for the cow with the large lactation average The difference was caused by differences in reproductive performance

The second strongest impulse in all nature is reproduction, the only stronger one being survival It should therefore be easy for herd managers to enlist the aid of nature in promoting dairy merit, but this is not always the case because nature has placed so much emphasis on the stronger sur-

Table 13-1. Effect of Reproductive Performance on Lifetime Production

	Cow 1	Cow 2
Age at first calving (years/months/days))	2 y 6 m 8 d	2 y 9 m 28 d
Second birthday to Last Dry Date (days)	2596 d	1985 d
Number of Lactations	9	4
Total Production (lbs)	71,247	38,273
Average Milk per Lactation (lbs)	7917	9568
Average Milk per Day (lbs)	27.4	19.3

vival impulse, and often factors involved strictly with survival are antagonistic to production and reproduction.

The anatomy and physiology of reproduction are covered well by excellent texts on these particular subjects. Nevertheless, a brief, general review is in order at this point.

THE FEMALE ORGANS

Consider first the ovaries (Figure 13-1). The ovaries are the egg-producing organs in the female. They are attached to the body cavity at the pelvic rim. The ovarian ligaments, the main attaching tissues, carry a rich supply of blood vessels, lymph ducts, and nerves. The outer layer of epithelial cells known as the germinal epithelium, proliferates at intervals to form ova, each of which is surrounded by a two-layer capsule. At this time the structure is known as a primary follicle. As the follicles develop, the follicular cavity fills with fluid which contains the hormone estradiol. At this stage the structure is known as a graafian follicle.

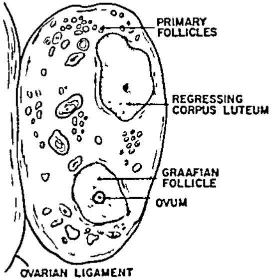

Figure 13-1. The ovary.

At the time of ovulation, the unfertilized egg (ovum) and the follicular fluid are forced out of the graafian follicle Normally they fall into the distal end of the oviducts (sometimes called fallopian tubes) It is possible for them to miss, however, and abdominal pregnancies occur at times

The follicular cavity collapses at the time of ovulation but the tissues remain nearly intact Later the cavity begins to fill with polyhedral (many-sided) cells containing a yellow fatty substance which may be the precursor of hormones The outer membranes of the capsule then send nerve tissues and blood vessels through the yellow cells and thus a tem-

porary endocrine gland is formed The temporary gland, the corpus luteum (yellow body) produces another hormone, progesterone Some progesterone may be released by the preovulatory follicles All stages of activity represented in Figure 13 1 usually occur at the same time in most normally functioning ovaries

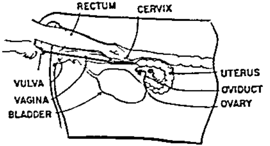

Figure 13-2 The female genital anatomy and artificial insemination by rectal palpation (Drawing by Elizabeth Ehrbar)

Figure 13 2 shows the gross genital anatomy Each oviduct has a funnel like structure (infundibulum) at the top to catch the ova at the time of ovulation The tubes are quite muscular and each has a rich supply of lymph and blood vessels They are lined with small cilia the purpose of which is not completely clear They probably help force sperm to the distal end of the oviducts

The uterus in the cow looks like the horns of a ram since it has a very little body and long curving horns The uterus has two layers of muscles and two layers of glandular tissues Its supply of blood and lymph is tremendous A great deal of uterine milk is secreted into its cavity, some of the secretions occurring about the time the ovum arrives This uterine milk is the only nourishment the zygote (fertilized ovum) gets from its environment during the first several weeks of pregnancy

Attachment of the embryo to the uterus is accomplished when the embryo forms two layers of tissue around itself The outer layer of tissue then attaches itself at many points in the uterus

At these points caruncles (projections) in the uterus enlarge many times The caruncles contain a very rich supply of maternal blood and the fetal membranes contain the main blood vessels to the embryo It is there that nourishment and waste products are exchanged across two membranes The process probably is one consisting largely of selective filtration

The cervix of the cow is much like that of other mammalian species It is from two to three inches long has longitudinal and annular folds, and

has columnar cells which secrete a viscous lubricating and cleansing substance during the heat period The main function of the cervix is to prevent foreign objects from entering the lumen of the uterus The cervical canal is closed at all times except during parturition, at which time it expands During pregnancy the cervical mucus hardens to form a seal Just before parturition the seal liquefies, probably because of hormonal action, and the cervix relaxes

The vagina also is like that of other species, being lined with epithelial tissues which cornify during the heat period and maintain minimum metabolism during pregnancy

THE ESTRUS CYCLE

The sexual cycle of the cow is easily described graphically as in Figure 13-3 The figure shows the various periods of the estrus cycle including two heat periods which are 21 days apart

In the figure, as we go from left to right, we come to the first estrus (heat), it is assumed that the cow was not bred at the first estrus At the second she conceived and some differences are apparent

Proestrum (extreme left) is the period of preparation for breeding Note that activity of the entire system is accelerated The follicle develops in the ovary, the uterus becomes turgid and gorged with blood The blood supply to the vagina is reduced, and hence the cells thicken and cornify somewhat This period lasts from 18 to 36 hours

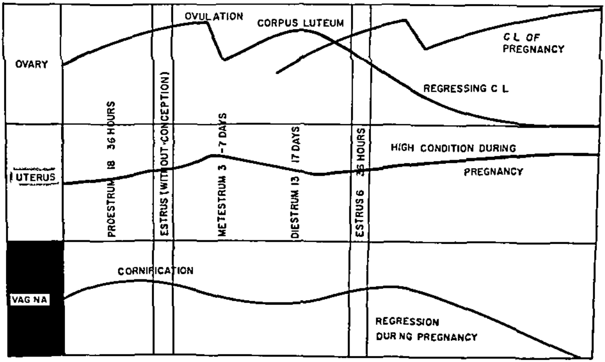

Figure 13-3. The estrus cycle.

The heat period varies from 6 to 36 hours, and sexual desire is the main physiological change, though there is usually an increased discharge of mucus especially from the cervix

The third period is metestrum No major change occurs in the organs for 7 to 15 hours after estrus Then the follicle ruptures, and 3 to 7 days are required for the corpus luteum to exert much influence, though the cavity left by ovulation is likely to be filled with luteal cells within 36 hours

During the next phase, diestrum, if the animal is not bred, the corpus *luteum begins to decrease in size and influence This happens after about* 16 days, then the cycle is repeated While the corpus luteum is effective, high condition of the genital tract other than the vagina is maintained In this state the cells are thick, secretions are copious, and a tremendous

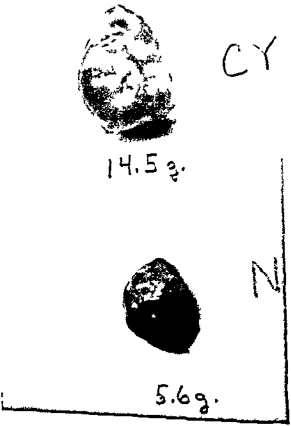

Figure 13-4. Comparison of a cystic and normal ovary. Note larger size of cystic ovary.

supply of blood is maintained in the area If the cow conceives, this is true throughout pregnancy Occasionally a pregnant cow will exhibit symptoms of estrus Careful records of breeding dates and pregnancy examinations should be available so that such animals will not be bred again It is likely, though not certain, that breaking the cervical seal with the inseminating tube will cause abortion

Most super heats occur at times which would not be expected from the normal time since the last previous heat period Another common malfunction is the occurrence of follicular cysts These are enlargements on the ovary formed by follicles which failed to ovulate Why they occur is not clear, but it is probably because of a hormone imbalance

Nymphomania often occurs concurrently with cystic ovaries (Figure 13-4) and hence they have been thought to secrete estrogenic substances While this may be true, it now appears that the secretion of cysts often contains progesterone This condition may be accompanied by the assumption of male characteristics Hence some authorities theorize that cystic ovaries may result from hormonal aberrations not of ovarian origin and may accompany, rather than being the cause of, nymphomania

Yet continued administration of estrogenic substances has caused the development of a raised tail head, sunken pelvic bones, and the tendency to bellow like a bull Hence it seems possible that follicles which fail to rupture continue producing estrogenic substances which cause nymphomania

THE MALE EJACULATE

The male reproductive cells are formed from germinal epithelium which lines seminiferous tubules throughout the testicle They finish maturation in a long convoluted tubule (the epididymis) at one side From there they go through the vas deferens (a tube that leads into the body cavity) Enlarged parts at the distal end of the vas deferens (the seminal vesicles) add fluids Other accessory glands (bulbo urethral and prostate glands) also add fluids, some of which activate the spermatozoa The penis is supported by the urenae muscle and the retractor muscle An S shape in the internal structure (sigmoid flexor) keeps the organ retracted within a glandular sheath except at the time of breeding The male genital tract is shown in Figure 13-5

The ejaculate is composed of approximately one-fourth sperms, one-half fluid from the epididymis, and one-fourth fluid from the accessory glands Usually a bull ejaculate comprises about 5 cc and may contain three billion to five billion sperms

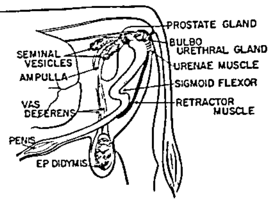

Figure 13-5 The male genital anatomy (Drawing by Elizabeth Ehrbar)

The following general considerations are based on physiological funda mentals some of which already have been discussed For the most suc cessful reproduction all of these must be observed

The cow ovulates about 14 hours after the heat period and during the heat period muscular contractions of the uterus and oviducts are most marked These muscular actions possibly stimulated by oxytocin during breeding are for moving the sperms close to the ovaries Thus breeding should be accomplished late in the heat period but not after it is over, if waiting this long is avoidable Although some sperms have been found at the distal end of the oviducts only a few moments after breeding from one minute to six hours are required for most of them to go from the cervix to the best point for fertilization

Placing the sperms further into the genital tract than the cervix does not cause them to get to the top of the oviducts appreciably sooner Even if they did, it wouldn t help because the male cell cannot fertilize an egg until it has been conditioned for approximately six hours in the fluids of the female genital tract Six hours before ovulation would seem to be the optimum time for insemination since most of the sperms should have tra versed the length of the tract during this period It is important for the manager to note however that ovulation can occur outside the general range of time It may happen at the very beginning of the heat period or a day after the symptoms of estrus have disappeared Such animals are not likely to conceive if bred according to usual recommendations Thus when cows fail to conceive and appear normal in all other respects per haps they should be bred at the onset of heat and again at about the end of the heat period Since normal muscular contractions will not occur under stress conditions all efforts to keep breeding cows calm, comfort able and healthy are easily justified

An ovum older than six to eight hours can be fertilized, but the zygote is not likely to mature Thus the cow should be bred sufficiently early so that the sperms will be waiting at the distal end of the oviduct when ovulation occurs Sperm cells are good for about 36 hours after ejaculation into the genital tract of the female If they are older than that, fertilization will be accomplished but maturation is not likely

The tail of the sperm is effective as an organ of motility to get it into the cervix The flow of mucus from cervical cells actually stimulates this activity while keeping bacteria out of the uterus Sperm cells have the power of rheotaxis, which means that they always swim *against* the current Thus under natural conditions, the flow of mucus from the cervix directs sperms into the upper genital tract, and at the same time it washes bacteria out

Usually if anything occurs to shock the sperms, the tails will appear abnormal Thus sperms with crooked, broken, or otherwise abnormal tails probably are infertile If the tails are not normal, the sperms probably are impotent If as many as 50 per cent of the cells appear abnormal, the entire ejaculate usually is discarded

The sperms can be shocked in the following ways (a) by cooling too rapidly, (b) by chemical action of substances like soap or residual sulfur in rubber parts, (c) by a few seconds of direct sunlight, which often causes the tails to curl, and (d) by the collecting equipment being too hot Although heating to body temperature from storage temperature does no harm, going very much above body temperature may cause shock

The Artificial Vagina

The artificial vagina still is used with most bull studs because it is inexpensive and reliable The artificial vagina consists of an outer jacket, inner liner of rubber, collection cone, and a collection vial It may be placed into an artificial cow but usually is hand-held while the bull mounts a real or artificial cow

Electro-ejaculation

The only other presently accepted method is electro-ejaculation A single electrode is inserted into the rectum at about the point at which the nerve supply to the genitals leaves the spinal column Stimulation at this point causes erection as well as ejaculation so that clean, completely normal ejaculates are obtained This system may be used easily with most bulls, though some animals exhibit temporary lameness after each use because of the effect on nerves to the rear quarters It is especially valuable, however, with old or injured animals which cannot mount

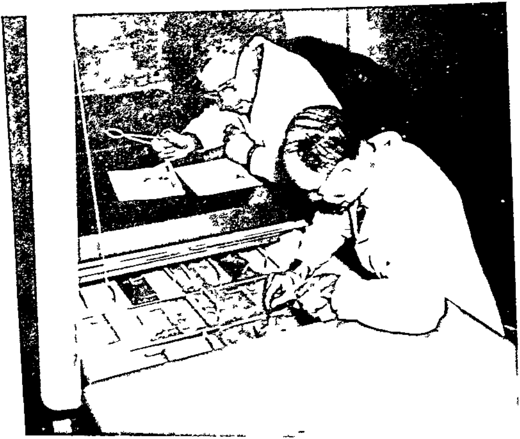

Figure 13-6 Labeling and cataloging semen (Courtesy Central Ohio Breeders Association)

In any event the collection must be made so that the semen is not shocked by cold or sunlight is not allowed to be contaminated, and is identified properly (Figure 13 6) The bull is kept as clean as possible, and preputial hairs (those at the end of the sheath) are kept clipped The general practice is to lead the bull by a cow several times thus teasing him and causing the secretion of precoital fluids which cleanse the prepuce

Extending the Semen

Various extenders are in use and the search for better ones continues In general it is necessary for anything used to extend the sperms to have the following properties

(1) It must contain nutrients

(2) It should help absorb physical shock since considerable movement of the diluted semen occurs during shipping and handling

(3 The diluent must be at the same osmotic pressure as body fluids to prevent rupture or crenation of the cells

(4) Metabolism of sperm cells continues to form carbon dioxide which is acid and must be neutralized constantly Thus all acceptable diluting solutions must be buffered chemically

(5) Of course diluents also must be nontoxic and must be economical, easily prepared, and it is desirable for them not to contain particles such as large fat globules which may make microscopic examination difficult

From the first, nonspecific bacterial contamination of semen has been considered a problem Some organisms are known to survive present freezing procedures

Although much research has been reported on small additions of chemotherapeutics and antibiotics to semen, the results are inconclusive It seems, however, that sulfanilamide, penicillin, and dehydrostreptomycin sulfate at respective levels of 3 milligrams, 500 IU, and 500 micrograms are effective against the organisms which cause most bovine reproductive diseases The effect of such additives on sperm metabolism needs further study

Milk would seem to have most properties of a good diluent, but in the natural state much of it is toxic to sperm It can be made useful, however, by raising the temperature of the milk to 92°C for 1 to 10 minutes Since the heating time can vary considerably, processing milk for use as a semen extender is easy, although the maximum temperature must be controlled carefully

The toxic milk factors appear to be associated with the albumin-fractions Pseudoglobulin appears to enhance sperm-cell livability Lactenin, an antistreptococcal substance of milk, is highly toxic to spermatozoa, and may account for most of the toxicity Yet, milk contains many enzymes which are destroyed by heating

At temperatures above 80°C, sulfhydryl groups may be liberated from some of the proteins, and these substances appear to reverse the toxicity of lactenin

Skim milk is preferable to homogenized milk because fat particles in homogenized milk make sperm counts very difficult Fresh milk, as opposed to the reconstituted products, is desirable This is because too much heat is likely to be involved in preparation of powders or concentrates Recently, use of reconstituted buttermilk as a semen extender has been quite successful, however

The egg yolk-citrate buffer is the most widely used diluent at present The citrate disperses the fat particles of the egg, making sperm counts easy Preparation is easy too fresh eggs are cracked, the yolk is separated, then a sterile glass rod is used to puncture the yolk outer membrane and the contents are poured into a sterile container The only other step involves mixing one part of 3 per cent sodium citrate with three parts of the

egg yolk liquid Sodium phosphate also can be used, but this buffer does not disperse the fat particles

Glycine with egg yolk or skim milk also offers considerable promise but it has not yet been thoroughly proved Equal parts of 0 5 M glycine and skim milk (or egg yolk) are mixed Another promising buffer contains one

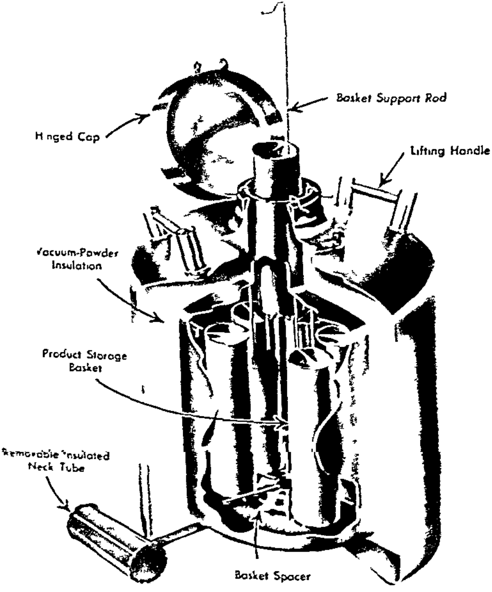

Figure 13-7 A liquid-nitrogen frozen semen container (Courtesy Linds Co)

part each of egg yolk, 5 per cent glucose, and 2 9 per cent sodium citrate dehydrate

Shortly after the semen has been collected, it should be subjected to an examination for color, volume, motility, and sperm count, the final diluted mixture should contain not less than 10 million sperms per cubic centimeter If the sperm count must be delayed, it usually is safe to dilute in ratios of 1 20 to 1 100, and this is done routinely with many studs Some mixtures are diluted 1 200 before the sperms are counted

The sperm count is accomplished the same way as a blood cell count, by the use of a standard haemocytometer with the customary allied equipment and solutions

Glycerol (7 to 16 per cent of the final solution) always is added if semen is to be frozen In some studs glycerol is added to fresh semen which appears to help longevity In frozen semen the glycerol replaces water and thus prevents crystallization which would kill the cells during thawing

The glycerol may be added at any time, but it must equilibrate at 5°C for several hours (18 hours seems best at this time) Usually, the glycerol is added when the semen reaches the 5°C level It must be cooled to this level not faster than 1°C per minute

The optimum rate of cooling after equilibration of the semen with glycerol has not been determined but it can be cooled at least as fast as 3°C per minute until reaching −15°C (Naturally the optimum freezing rate can be expected to vary for various diluents) Then it is reduced at the rate of 5°C per minute to −79°C or −196°C, the respective temperatures of dry ice and liquid nitrogen

One word of caution is necessary Occasionally glass ampules leak, allowing liquid nitrogen to enter When these containers are warmed, they may explode A liquid nitrogen semen container is shown in Figure 13-7

Plastic ampules may be used but they have not been satisfactory for storage in liquid nitrogen as yet When they can be used, plastic ampules are preferable to glass ampules because the former are sealed with pressure Glass ampules must have long necks so the sealing points can be away from the semen since they are sealed by heat Thus glass ampules are longer and require more space for storage than do plastic containers

Insemination

The cow is bred during the last part of the heat period This allows the sperms to be properly conditioned and waiting at the distal end of the genital tract when ovulation occurs Since sperms do not propel themselves through the genital tract after reaching the cervix motility is of importance only as an index of general health The same applies to the shape of the tails

Since sperms must be conditioned for longer than it takes for them to reach the distal ends of the oviducts intra uterine deposition is not necessary Furthermore it could be detrimental Bacteria cannot get through the cervix because mucus secretions keep them washed out It would be quite easy for them to go through on an inseminating tube

The only acceptable technique for insertion of the tube is cervical fixation by rectal palpation One hand is inserted into the rectum and the cervix is palpated through the rectal wall (Figure 13 2) Plastic or rubber gloves lubricated with mineral oil or other nontoxic materials are used The tube containing the diluted thawed semen then is inserted However, the tube is not forced through the cervix To prevent injury the cervix is worked over the end of the tube

In some cases there will be a tightening of the rectal muscles making free movement of the cervix difficult In these cases which are relatively few the semen should be expelled onto the cervix and the tube withdrawn without forcing the cervix over the tube since the chance of injury is not justified by the slightly higher conception rate

Pregnancy Diagnosis

At 40 to 60 days after conception pregnancy can be diagnosed The uterus feels enlarged and the corpus luteum can be felt on the ovary If the uterus is not enlarged but a corpus luteum is found this is a false pregnancy and a competent veterinarian should remove the corpus luteum by hormone or manual treatment A technique for pregnancy diagnosis at very early stages now being developed involves the contraction of vaginal muscles in response to injected oxytocin Although not yet in popular use this method holds considerable promise

ENDOCRINE FUNCTIONS

Under the nervous control of the hypothalmus the system of regulatory hormones is controlled by the anterior portion of the pituitary gland as shown in Figure 13 8 The posterior lobe of the pituitary acts as a specific endocrine organ Precursors and perhaps even some of the actual hormones from the posterior pituitary are thought to originate in the hypothalamus

There are two principle secretions from the posterior lobe pitressin has an antidiuretic effect and stimulates smooth muscles of the intestines and blood vessels Pitocin or oxytocin causes contractions of the smooth muscles of the uterus Probably this function helps in the transport of sperms at breeding and delivery of the calf at parturition It also stimulates the smooth muscles around udder alveoli and ducts

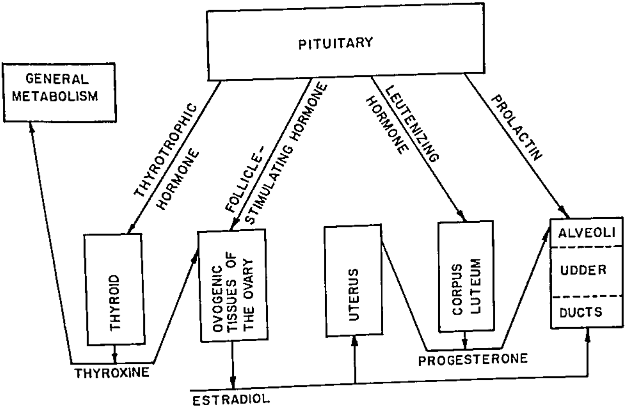

Figure 13-8. Hormonal control of production and reproduction.

Probably both fractions have other functions also, though animals have been observed to remain healthy after removal of the posterior pituitary The chances are that some other part of the body is stimulated to take over the functions at the expense of adaptive energy, of course

All permanent parts of the endocrine systems are active at all times, the interrelationships of various components governing largely the extent to which each gland is active Although each hormone is designated according to its most spectacular effect, all of them influence general metabolism, and all are involved in energy transformation

General metabolism is influenced directly and indirectly by various secretions, including thyroxine, most of the other hormones play a lesser role in general metabolism Thyroxine and the adrenal hormones are essential for normal reproduction in males and females The adrenal hormones may to a partial extent act indirectly through the pituitary It appears that some sex hormones are formed in the adrenal cortex and that some of these are quite similar to those produced in the sex glands

The gonadotrophic complex is a combination of at least two hormones which vary in relative amounts Follicle-stimulating hormone (FSH) causes the development of the graafian follicle and the subsequent production of estradiol The estradiol possibly acts back on the pituitary, limiting further secretion of FSH to maintain some order in ovulation

Estradiol also causes the heat period and the accompanying change in the genital tract In addition this hormone is associated with development of the duct system of the udder

Leutenizing hormone (LH) causes formation of the corpus luteum which subsequently produces progesterone which in turn probably inhibits both FSH and LH to some extent so that ovulation will not occur during pregnancy Just how the hormones are coordinated for maintenance of pregnancy is not clear It seems logical however that the origin of the mechanism is in the uterus by the fetus The impulse appears to be transmitted to the hypothalamus and from there to the pituitary gland which regulates the ovarian activity

Clearly FSH and LH are never secreted separately There is some evidence that the production of FSH is steady and that variance of the LH causes cyclic changes

Progesterone appears also to be involved with maturation of the secretory tissues of the udder It maintains the high condition of the uterus but allows the squamous epithelial cells of the vagina to regress during pregnancy Thus the vaginal wall is thickened and hardened somewhat during the heat period During pregnancy the wall becomes relatively thin and noncornified cuboidal cells predominate

At the time of parturition various hormonal and other relationships probably are necessary to normal birthing and the normal initiation of lactation

14 HERD REPLACEMENTS

THE MOST IMPORTANT PART OF THE REPLACEMENT PROGRAM BEGINS BEFORE the calf is born Expectant mothers in the herd need rest, attention, and special feeds Most growth by the unborn animal occurs during the last two months of pregnancy Therefore all lactating cows should be dried off and heifers calving for the first time should begin to receive special attention two months before the expected calving date The dry cows and pregnant heifers should be fed all the good quality leafy roughage they want during this period Palatable bulky concentrates containing sufficient proteins to insure the requirements of the mother and calf should be supplied The amount of concentrates must be adjusted often enough to keep the mother on feed and in a thrifty but not fat condition Care should be taken to include sufficient mineral matter in the ration A few days before calving it helps to increase the bulkiness of the feed by adding wheat bran High energy ingredients such as corn or citrus pulp can be included also during this time Although prepartum feeding practices can vary considerably, most cows should be on full feed and in a vigorous condition at calving time

THE CALF AT BIRTH

During the winter in cold climates, use of the maternity stall is advisable, and clean, well-bedded stalls in a reasonably warm barn help prevent many calfhood troubles However, during mild weather a clean, grassy lot or small pasture with shade or shelters apart from the other animals is preferable The maternity facility should be located close to the main building so attendants can check often and help during calving if necessary

As soon as the calf is born, the navel should be disinfected with iodine or gentian violet It should not be tied but may be clipped after a few days if this seems desirable

Under most conditions the calf will be on its feet and ready to eat within an hour Much infection can be prevented if an attendant cleans the udder before the calf nurses

Usually the calf should be separated permanently from its mother after the first feeding When maternity barns are used some dairymen prefer to leave the calf with the cow during the colostral period Although this saves labor it could waste colostrum and cause more distress to the cow and the calf than if the separation had occurred on the day of birth

Occasionally it is necessary to remove membranes or mucus from the calf s nasal passages (Figure 14 1) Even then some calves do not begin breathing spontaneously and artificial respiration may be necessary This is accomplished by laying the calf on its side and depressing and releasing the ribs rhythmically at three second intervals A few minutes of this generally starts normal breathing

Figure 14-1 The newborn calf usually is covered with a membrane which could obstruct the nasal passages and *smother the animal if not quickly removed*

In cold climates it often helps to dry the calf Turkish towels are the best material to use though they are costly The mucus which covers a newborn calf is difficult to remove and attempts to dry calves with old feed bags or smooth cloths usually results in little more than moving the material around Of course even this helps by stimulating the calf's circulation

DETERMINING WHETHER TO RAISE OR BUY REPLACEMENTS

A breeding program in which offspring are at least equal to their dams is the only practical means of maintaining high quality in good herds and of improving average herds

Artificial insemination with preserved semen has made superior sires almost universally available The average production in most (though of course not all) herds where all replacements are purchased has not changed materially during the last 20 years, yet some commercial dairymen continue buying rather than raising replacements The reason usually given for lack of a breeding program is, "It costs more to raise calves than to buy springing heifers just prior to the season during which the demand for milk is the greatest "

That statement is true under some circumstances, but if it held consistently, no one could afford to raise calves, and soon there would be no place to purchase replacements

Cost of Raising Calves

To serve as a guide, the data in Table 14-1 were collected over seven years from the Jersey herd at the Florida Agricultural Experiment Station Under these conditions the cost of raising heifers from birth to

Table 14 1 Feed and Labor Used and Estimated Cost in Dollars of Raising Jersey Heifers

	Cost ($)
From birth through five months	
(1) Feed	
(a) Colostrum (45 lbs)	free
(b) Skim milk or milk replacement formula (300 lbs)	6 00
(c) Concentrate feed (284 lbs)	12 00
(d) Hay (254 lbs)	5 00
(2) Labor 7 man hours (by skilled calf feeder)	14 00
From five months to calving	
(1) Feed	
(a) Four to 500 days on pasture (average calculated TDN, 3752 lbs) Cost of fertilizer, seed, machinery, land, and farm labor	60 00
(b) Hay (1110 lbs)	22 00
(c) Concentrates (1200 lbs)	40 00
(2) Management, breeding, incidental	25 00
TOTAL	184 00

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calving was $184 00 The monetary evaluation will change, but the data relative to feed and labor should be representative of typical dairy herd replacement operations for an indefinite time

The value of these heifers was considerably more than their cost Actually the cost was less than the price for heifers of unknown breeding during the same period

Feed cost, where hay and silage supplied most of the leafy roughage, was somewhat higher Under these conditions at the Ohio Station, feed cost alone was $168 00 for small breeds [6]

Expenses Other Than the Original Price

There are expenses other than the original price for purchased replacements

(1) A 60 day (preferably 90 day) isolation period is desirable for all new cattle to reduce the possibility of bringing disease into the herd

(2) If the animals have been moved long distances, often a period of several months is necessary for them to become acclimatized, or to recover from the trip

(3) The purchase of heifers usually requires a large cash outlay The cost of raising replacements, on the other hand, is spread over a period of two years However, in raising heifers, interest on capital is encumbered for considerable time before any return is realized

(4) Home raised heifers usually are healthier than imported ones Thus, veterinary costs are likely to be lower in a home raised herd

The feeding and management of purchased replacements may have been the best, but any dairyman who purchases replacements as a routine part of his business sometimes may obtain heifers which have not had proper care Replacement stock does not have to be pampered Nutritional deficiencies can occur, however without changing the appearance of the animals This may result in subnormal production, inefficient reproduction, and shortened lives

Superior health in home raised heifers is indicated by results of various surveys In Connecticut home raised cows stayed in milking herds an average of 4 0 years compared to 2 6 years for purchased replacements [7] In Florida, the differences were more pronounced 4 8 years for home raised and 2 5 to 3 0 years for purchased replacements [1]

A recent survey of New Hampshire dairies showed the opposite trend, however Under these conditions the average age of disposal for nondairy purpose for purchased cows was 7 06 years, compared to 5 74 for raised cattle Apparently these cattle were purchased in small numbers and were selected carefully after having shown themselves to be vigorous producers In the large commercial herds around large cities, particularly in the south, springing heifers are purchased by the truckload without an investigation of

background, and this may account for some of the discrepancy. An extensive economic analysis indicated that dairies in this New Hampshire area could best use available labor and feed to increase the number of cows and to purchase replacements as needed.[5]

Dairymen in such areas can maintain a breeding program by contracting their replacement raising with people who specialize in this phase of dairying. Thus many of Florida's calves are shipped to Tennessee. Wisconsin and Minnesota dairymen supply calves to many areas where raising them is not practical. Legislation has been enacted in some states to govern this important new business.

Obviously, many dairies could increase production permanently by improving herd quality through a constructive breeding program. Moreover, in the long run such a program would be cheaper than any other method.

One reason that some dairymen do not raise their own replacements and that purchased heifers are so expensive is the high mortality of young calves. Despite the efforts of researchers and managers to reduce calf losses, an average of 34 per cent of heifer calves still fail to enter milking herds.

FACTORS IN CALF MORTALITY

Most calf mortality seems to be connected in part with failure to consider principles of the natural processes. In nature, all mammals nurse their mothers until solid feeds can be consumed in quantities sufficient to maintain normal growth. Young mammals are born with little protection from disease.

Colostrum (the first milk produced when a cow freshens) contains antibodies which help protect the newborn calf against many common kinds of bacteria. As animals become older, their bodies develop antibodies gradually. Thus they outgrow their need for antibodies in the feed. Such antibodies are formed as the *result* of bacterial invasions, and hence they are not present to combat the first attack.

Since the cow is protected by antibodies (and they are in her blood), why doesn't she pass this protection along with nutrients to the calf before it is born? The antibodies are associated with gamma globulins (protein molecules which are too big to pass through the fetal membranes). Hence the calf is vulnerable to bacterial invasion until antibodies can be acquired or produced within its body. This problem is solved partially by the fact that the first milk (colostrum) contains a high concentration of antibodies.

Value of Colostrum

In addition to its content of antibodies against many disease organisms which the cow has contacted in her lifetime, colostrum has other especially valuable properties.

(1) It is high in solids, it contains as much as 27 per cent dry matter, compared to an average of 13 per cent in milk which is produced later in lactation
(2) Colostrum contains a large quantity of Vitamin A, and most calves are born with a deficiency of this nutrient
(3) The first milk is very high in protein, the kind of protein which is especially needed by young animals
(4) It is laxative and stimulates activity of the digestive tract

Colostrum, as such, usually is produced for only 2 to 4 days, and the main antibody content seems to decrease rapidly following the second day

PROTECTIVE FUNCTIONS OF THE UDDER

Since at least two weeks apparently are required for the young calf to become immunized, how does nature take care of this rather alarmingly long period between colostral antibodies and naturally acquired bacterial antibodies in the body? Workers at the University of Minnesota have found that the cow's mammary gland produces antibodies against bacteria which contact it [10] This reaction occurs within a few hours Thus it seems likely that a calf, after contacting bacteria, nurses its mother and puts a sample of the organisms it has contacted into the udder At the next nursing period, the milk will contain a high concentration of antibodies against *just those* particular organisms

The Minnesota workers *purposely* infected the udders of special cows with organisms which cause most calf losses The milk from these cows was dried without destroying the antibodies and included in milk replacement formulas where it prevented disease [10]

It appears that gamma globulin, as such, can be absorbed directly into the blood stream for only a few hours after birth [12] Bovine gamma globulin apparently is not absorbed by humans either [3] How milk-borne antibodies benefit older calves is not clear Perhaps they protect the calf from bacterial invasions via the digestive tract In any event dietary antibodies seem effective in reducing calf mortality Thus a practical answer to many calf health problems would seem to be right on the farm Most cows produce considerably more colostrum than their calves can use at the time

METHOD OF USING COLOSTRUM

Colostrum is valuable feed, and good herdsmen feed the surplus to the older calves The usual plan is to start each feeding with the youngest animals feeding the oldest ones last Thus the newborn calves always receive colostrum and most of them get some colostrum for the first two weeks This is a good system, by the time colostrum is no longer available the calf probably has become immunized by contact with the most serious disease organisms

A better system, however, which requires somewhat more labor, is to stretch the colostrum by diluting it with an equal volume of skim milk or a liquid milk replacement formula Thus, colostrum alone is fed for only four days which is the usual colostral period After that, a mixture of half colostrum and half skim milk is used The composition of colostrum changes rapidly after the first day, but usually the milk is not normal nor saleable until the fifth day The term "colostrum" as used here refers to a blend of the first four days' milk Data accumulated for five years at the Florida Station show that average production of colostrum, considered in this way, is sufficient to supply all calves for the first three weeks of life Where mainly heifer calves are raised, and this applies to many commercial herds, it is possible for colostrum on a diluted basis to be available for 4 to 6 weeks

ADDITIONAL MILK FEEDING

Colostrum is a good feed for calves of any age, but calves over three weeks of age have no special need for it This is because their bodies have manufactured antibodies, the rumen and reticulum have become functional,[13] and Vitamin A has been acquired

Digestive upsets and bacterial infections are the most serious threats during the early life of the calf Most difficulties associated with the milk feeding period can be eliminated by observing a few precautions

(1) Do not feed more of any milk than 10 per cent of the calf's body weight daily This should be given in not less than two feedings

(2) It seems best to feed liquids at temperatures of 90 to 100°F Cold milks alone probably would not be detrimental but accompanied by any other irregularity their use could result in serious digestive trouble

(3) All milk should be fresh Frozen colostrum should not be thawed until the day it is to be fed Milk powder to be reconstituted should not be mixed with water until just before feeding

(4) Regular feeding hours should be observed If twice a day feeding is practiced, a 12-hour interval between feedings should be maintained when possible

(5) Keep all utensils for calf feeding clean It is a good idea to sanitize them with the same materials used on the milking equipment

(6) Reduce the feed intake if scours or other digestive troubles occur Bring the feed back to normal gradually after the trouble is remedied

(7) If colostrum is not available or if disease is an outstanding problem, young calves can be passively immunized by transfusions of their mother's blood About 100 cc of blood can be taken from either a milk vein or the jugular vein with a needle A few drops of a citrate solution will keep it from clotting The blood is given under the skin of the calf in several places Blood type is no problem when this method is used

Types of Pails

When milk is fed from a nipple pail, as shown in Figure 14-2, it trickles through the esophageal groove into the true stomach If an open pail is used, the calf is likely to drink in large swallows which may force the esophageal groove open, causing milk to spill into the rumen There it is likely to putrefy if the calves are less than three weeks old because the rumen of younger calves does not contain the enzymes which digest milk Thus, harmful putrefactive end products are produced and may cause scours or even death

The calf's stomach develops rapidly Although nipple pails are desirable for feeding milk to newborn calves, there is no point in continuing this practice after the calves are three weeks olds The entire stomach begins functioning by then, and thus if some milk does get into the rumen, such decomposition products as are formed are not likely to be harmful

Weaning

At what age can milk feeding be eliminated safely? There is no simple answer Various systems include weaning at ages of four days to six months

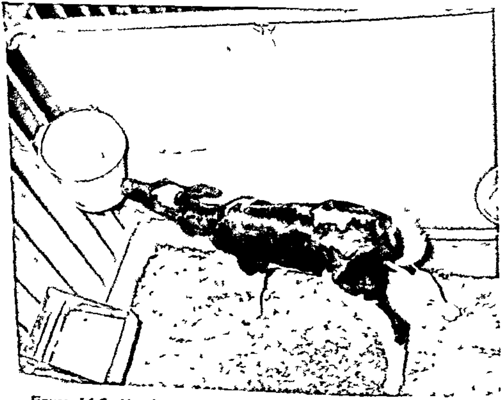

Figure 14-2 Nipple pails should be used during the first three weeks

Fermentation is well established in the rumen of calves at three weeks of age if solid feed has been available. Thus after this time they should remain healthy and grow on good hay and concentrate feeds alone. Some calves much younger than three weeks can subsist on solid feeds. Three weeks appears to be the minimum age at which adequate growth on hay and concentrates can be expected to occur routinely, however.

Since use of the open pail is permissible for feeding liquids to calves over three weeks of age, many managers use some milk until the calf is two months old or has doubled its birth weight. After this, feeding milk probably should be discontinued to encourage full use of solid feeds. Various systems for feeding young calves are exhibited in Table 14-2.

Liberal Milk Method

Sometimes market conditions leave the dairyman with surplus milk which often can be utilized better by feeding it to calves than by selling at manufacturing prices. Maximum growth can be obtained by this method. The advantages of the extended colostrol system still applies, but whole milk is used rather than replacement formulas or reconstituted skim milk.

Limited Whole Milk

Some dairymen prefer to use only whole milk, but do not have liberal quantities. Because of this, dry feed can be allowed to make up a larger and larger share of the feed as shown in Table 14-3. The maximum time which should be allowed to achieve complete substitution is seven weeks, although frequently solids can be substituted entirely at three to four weeks of age. Where the limited whole milk system is used, a calf starter which is high in protein is desirable. As milk is withdrawn, most calves consume increasing quantities of the starter mixture.

For all systems, however, hay and some type of concentrate feed should never be delayed beyond three weeks of age, and it can be started at any time. Some calves will begin nibbling at concentrates or hay during the first week (Figure 14-3.) All four parts of the stomach usually are functioning when the calf is three weeks old.

Hay for calves must be of high quality for several reasons. (1) Good quality hay is likely to be palatable and thus it encourages young calves to begin consuming solid feeds at an early age. (Of course, poor quality hay also may be palatable, particularly if caramelization has occurred.) (2) The protein needs of growing animals are relatively high, bright, clean-smelling hay is likely to contain more protein than is found in bleached, musty hay. (3) Vitamin A precursors are associated with green color.

Generally, concentrate feeds for calves are high in protein and low in fiber. Since it is known that the rumen is completely functional at about

Table 14 2 *Principal Systems of Feeding Dairy Calves from Birth to 6 Months of Age*

Feeds	Extended Colostrum Method		Nurse Cow Method		Liberal Milk Feeding (Whole and Separated Milk Available)		Limited Milk Feeding (Whole Milk Available)	
	Age (Days)	Amount Daily Per Calf (lbs)	Age (Days)	Amount Daily Per Calf (lbs)	Age (Days)	Amount Daily Per Calf (lbs)	Age (Days)	Amount Daily Per Calf (lbs)
Colostrum	0-4	6-10	0-4	free choice	0-4	6-10	0-4	6-10
Whole milk	—	none	4-120	free choice	4-28	6-12	4-42	6-10
Blended colostrum and skim milk	5-30	6-12	—	none	—	none	—	none
Separated or reconstituted milk	31-60	10-16	—	none	29-120	10-16	—	none
Calf starter	—	none	—	none	—	none	14-120	free choice (up to 4)
Concentrate mixture	1-180	free choice (up to 4)	14-180	free choice (up to 4)	14-180	free choice (up to 4)	121-180	free choice (up to 4)
Hay	1-180	free choice	14-180	free choice	14-180	free choice	14-180	free choice
Silage (optional)	1-180	free choice	120-180	2-8	120-180	2-8	120-180	2-8
Pasture (optional)	1-180	free choice	120-180	free choice	120-180	free choice	120-180	free choice
Water	42-180	free choice	42-180	free choice	42-180	free choice	21-180	free choice
Salt	14-180	free choice	14-180	free choice	14-180	free choice	14-180	free choice

Table 14 3 Limited Whole Milk Feeding Plan for Raising Dairy Calves (after calf has been left with dam for 3 days)

Week	Milk daily (lbs per 100 lbs birth weight of calf)
1	8
2	9
3	10
4	9
5	7
6	6
7	4
Thereafter	No Milk

the time that solid feeds are first consumed in significant quantities, the fiber content need not be particularly low Experience over a two-year period at the Florida Station showed that a concentrate ration containing 14 per cent fiber was at least as good for young calves as a complex calf meal containing only 6 per cent fiber [16] Any good cow feed should be adequate for young calves which also are fed milk (including diluted colostrum) and good quality hay

HOUSING AND MANAGEMENT

Housing for calves need not be elaborate, but must meet these conditions (1) The surroundings of young calves must be clean and dry (2) Young calves should be confined to individual pens (Figure 14-3) Where this cannot be done, they must be divided into groups of about the same age Individual stalls may be used in group pens, as in Figure 14-4 This system offers many advantages labor-wise, since automated systems adapt easily to group handling (3) Cold air is not detrimental but drafts and wet quarters cannot be tolerated (4) The area in which solid feeds are offered must be protected from rain

Portable Pens

Portable pens (see Figure 14-5) with one end closed on three sides are becoming popular because they offer an inexpensive means of providing the above conditions These pens are placed on clean permanent pastures which have been established long enough to develop thick sod which serves as bedding for young calves The pens are moved frequently to clean ground It is preferable to move portable units uphill to prevent recontamination from previous sites In the northern hemisphere during the summer and fall months, the enclosed part of the pen is pointed west be-

Figure 14-3 A four-day old calf eating grain

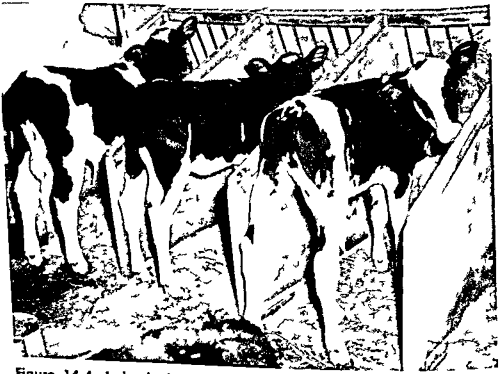

Figure 14-4 Individual stalls prevent vices and promote calf health (Courtesy Holstein Friesian Association of America)

cause the most uncomfortable rays of the sun come from that direction. In the winter months, warm sun rays slant in mainly from the south, and thus the open part is pointed south to catch the warmth of the sun. The closed end then is on the north side from which cold winds are most likely to blow.

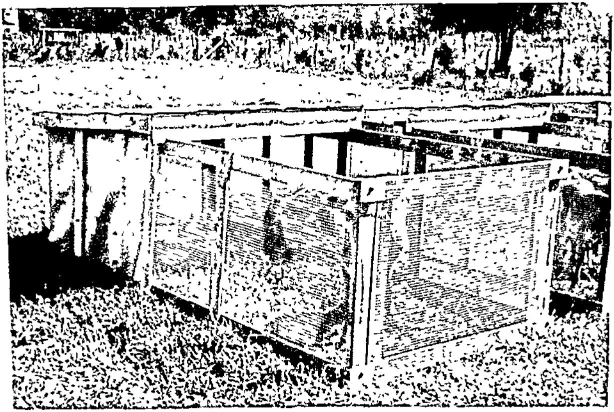

Figure 14-5. Individual pens with draft-free enclosure of metal roofing and plastic treated wire.

Although many dairymen in northern sections find closed barns preferable, elaborate housing is never necessary. Calves kept in open pens in Bulgaria where temperatures reached −10.3°F were healthier than comparable calves kept in closed stall barns.

Before calves leave the individual pens, they should be dehorned and marked for identification, and any extra teats should be removed.

Dehorning

Dehorning may be done by various methods: (1) The horns can be removed surgically using special spoons, tubes, or scoops. (2) Chemical dehorners containing caustic substances and a pliable film may be painted on. (3) Electric dehorners which work by heat also are becoming popular (Figure 14-6). The latter two methods kill cells around the base of the horn. All three methods are effective and accomplished easily when calves are in

Figure 14-6. Using the electric dehorner.

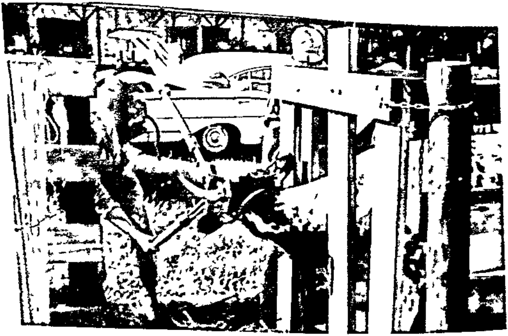

Figure 14-7. Dehorning older animals.

Figure 14-8. Tattooing the ear.

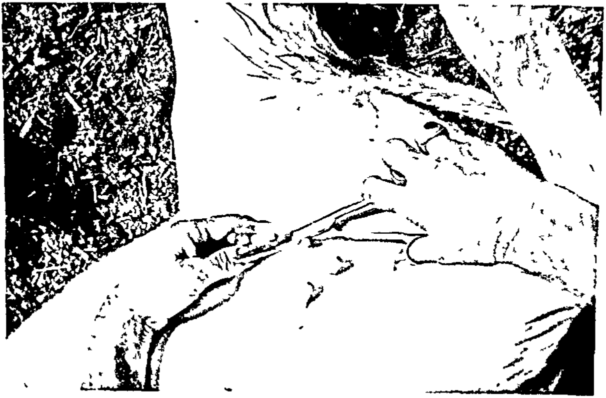

Figure 14-9. Removing an extra teat.

the preweaning stage Older animals are more difficult to dehorn (Figure 14 7)

Identification

Tattooing between the large veins of the ear as shown in Figure 14 8 is the most reliable method of identification It is a good idea to be consistent in putting the herd number at either the top or bottom leaving one part for the veterinarian to record dates and immunization when he vaccinates against brucellosis and blackleg when heifers are about six months of age

Sometimes it is desirable to use ear tags for identification until the calves are old enough for vaccination By this time the ear has thickened considerably and a permanent tattoo is much easier to accomplish than with the very young calves

Extra Teats

Extra teats occur in about 40 per cent of all heifers Most of these are behind the normal teats As soon as it is possible to distinguish between normal and extra teats the extra ones can be removed easily with surgical scissors (Figure 14 9)

TURNING CALVES OUT

Generally calves are kept off pasture until they are six months old Since the entire digestive system is functional at less than one month of age however there is no scientific basis other than parasite control for this usual recommendation This likewise seldom is a problem when pastures are rotated frequently and other feeding and management practices are adequate [15]

Clean water must be provided Swamps ponds sloughs and any other source of stagnant water must be eliminated or fenced off Overstocking pastures is one of the most serious mistakes The grazing areas should be relatively small so that the vegetation can be grazed down in a few days and the animals moved to a fresh area

Calves should be segregated into age groups for parasite control as well as for other managemental practices

Rotation periods of six months or less materially help parasite control and a year of nongrazing will almost completely eliminate the causative larva Rotation of pastures with horses or pigs is another approved means of eliminating cattle parasites

Calves should never graze with mature animals Feed bunks should be provided in all calf pens Feeds picked up from the ground are likely to be infested

Calves in New Zealand are reported to thrive on pasture when only two weeks old [9] English workers showed that nine weeks-old calves digested

high quality forage as well as it was digested by mature cows [11] Moreover, these workers raised calves on pasture from the age of one week, and the pasture-raised calves were fully as healthy as comparable barn-raised animals Whole milk was supplied through six weeks of age It should be mentioned that excellent pasture is necessary for the success of this system Otherwise, grain and/or good quality hay are necessary

Where pastures are kept in the best stage by a succession of highly fertilized annuals, milk may be eliminated after the colostral period Louisiana workers,[4] raised Holsteins to 24 months for $65 74 and Jerseys for $60 14 This compared to $199 01 and $180 69 for similar heifers started in the barn and raised on grain in addition to hay, silage, and pasture Under the conditions reported, the pasture-raised animals grew faster, had less digestive and parasite troubles, and looked better

Unless ideal pasture conditions are assured this would seem to be a system to approach with caution, but certainly not one to ignore

There seems to be no single answer to the question of the age at which calves can begin to utilize pastures It is evident, however, that green feeds are consumed in significant quantities at a much earlier age than was thought previously In fact, workers at the Kansas Experiment Station have shown that green feeds are especially valuable for very young calves [2] They found that grass juice stimulated growth as much as various chemical and antibiotic growth promotants did

RAISING VEAL CALVES

Generally, there is little point in raising any grade bull calves or the majority of purebred males to maturity The easiest way to dispose of them profitably may be as veal, which usually commands a good price But it is costly to produce because it involves use of large amounts of milk Production of first-class veal is accomplished with very limited amounts of solid feeds

The veal calf which brings the top price is one weighing about 200 pounds The meat must be of fine grain and light color

The first question that arises is whether the price of veal is enough to compensate adequately for the production costs All previously recommended systems of veal feeding involved almost exclusive use of whole milk This method requires an average of 10 pounds of milk for each pound of gain in body weight The cost of raising veal calves is easily computed as shown in Table 14-4

When labor and the possibility of losses due to disease and accidents are considered, it appears that only very large calves can be used for veal when the whole milk system is used unless surplus milk is available

Table 14-4 Relation of Birth Weight to Cost of Feeding Veal Calves to 150 Pounds

Birth Wt (lbs)	Amount of Milk (lbs)	Value of Milk at $4 00/cwt ($)	Value of Colostrum-High Solids Milk at $2 30/cwt ($)	Value of Veal at $25 00/cwt ($)
40	1100	44 00	15 18	37 50
50	1000	40 00	13 80	35 00
60	900	36 00	12 42	35 00
70	800	32 00	11 04	35 00
80	700	28 00	9 61	35 00
90	600	24 00	8 28	35 00
100	500	20 00	6 90	35 00

Calves raised by the extended colostrum method require much less valuable feed In the case of veal calves an additional feature is suggested They are fed according to the usual schedule, 0–4 days, colostrum, 5–21 days, ½ colostrum plus ½ skim milk, and thereafter, skim milk The skim milk (or calf starter) in this case, is reconstituted to contain 20 per cent whereas normal skim milk contains about 10 per cent of air dry solids Calves fed in this way at the Florida Station have grown significantly faster than control calves fed normally, and have been equally vigorous

Approximately six pounds of milk per pound of gain in weight are required under this system Although less expensive than whole milk, the series of milks used in the extended colostrum high solids system is considerably higher in nutrients

The colostrum is free and skim milk powder of animal grade often is available for 5 to 12 cents per pound Thus an average figure of $2 30 per cwt would take into account the labor and refrigeration costs Since calves on this system grow almost 50 per cent faster than average calves, the total labor requirement is less The requirement for meat produced mainly from milk is met Calves fed high solids milk have little tendency to consume concentrates or hay

When extra milk solids can be supplied even relatively small calves can be used for veal if the labor requirement is not prohibitive

The extended colostrum part of the proposed system is essential, otherwise milks above 13 per cent in solids are likely to cause severe scouring

RAISING HEIFERS AFTER WEANING

After weaning heifers are easy to raise Any shelter which affords protection from blowing rains is adequate (Figure 14 10) The feed also may be simple Any good leafy roughage (preferably lush pasture, although

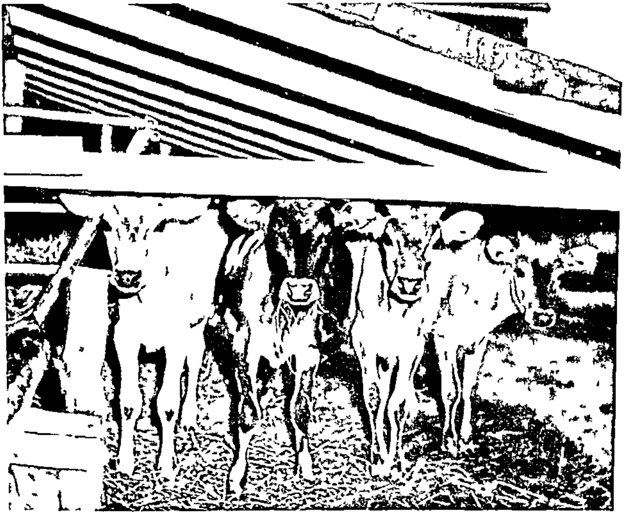

Figure 14-10. Replacement calves seek protection from the rain under a feeding shelter. (Courtesy U. S. Dept. of Agriculture)

silage and/or hay are satisfactory) will supply a large part of the nutrient requirements. Only enough concentrates should be supplied to keep the animals growing without getting fat. This is the part of the replacement program which is most difficult for large dairies close to concentrated population areas because of the space problem. For this reason many heifers are grown out in other areas. Some dairymen maintain farms for this purpose, whereas others have the replacement heifers raised by contract. The contract replacement business is a good one for farmers away from congested areas.

Overfeeding of heifers is possible during at least two periods. If 4 to 6 months old animals are penned with very young calves, the older calves are likely to overeat by consuming the concentrates supplied for the young calves in addition to their own feed. Therefore, replacement stock must be kept separated into groups of about the same age at least during their first year. Sufficient good quality leafy forage to support normal growth, plus not more than 4 pounds of concentrate feed per head daily is desirable.

Between one year of age and calving, if plenty of roughage is available, overeating seldom causes digestive troubles However, too much high energy feed during this time could cause excessive connective and fatty tissue to form in the udders [14] However, this happens only in heifers which acquire excessive body fat Vigorously growing heifers with the angular conformation characteristic of fine dairy cattle are affected less often The amount and type of concentrate feed can be adjusted according to appearance of growing heifers Fine heifers are raised routinely at the Florida Station mainly on corn silage and cottonseed meal pellets, plus grass, hay, and pasture when it is available

During the last two months before calving, regular herd concentrates are likely to be needed The amount should be sufficient to keep the heifer in good flesh but not fat High protein concentrates in realistic amounts (4 to 6 pounds per head daily) often are necessary to condition the heifer for the rigors of heavy milk production Properly conditioned heifers are thought to have considerably less trouble with retained placentas, milk fever, and ketosis than do underfed or excessively fat animals

BREEDING HEIFERS

All normal heifers may be bred when they are 15 months of age, usually earlier if the small breeds weigh as much as 550 pounds and the large ones 700 pounds or more, provided this weight is not caused by excess fat

About two months before calving, young heifers should be confined to a clean pasture close to the main farm building where they can be inspected frequently During the last month before calving they should be walked through the milking parlor or fastened frequently with the herd during milking Thus, they will become accustomed to the surroundings and activity and will be less nervous during the first few milkings During this conditioning period, the udders must be inspected Mastitis may occur just before the first calving Prompt discovery and treatment may increase materially the whole lifetime production This is a good time also to trim hooves and clip the hair at least on the udder and belly

DAIRY BEEF

Male calves which do not reach market weight at a favorable time for vealing may be fed out and sold as fat steers One should keep in mind, however, that the steer enterprise could be expensive in both time and feed

Dairy steers seldom grade higher than standard to good This does not mean that they are never profitable When a dairyman has a plentiful supply of feed (particularly leafy roughage) and can avoid extra investment in buildings, equipment, and labor, steer feeding could be a profitable

sideline. However, he must control costs more closely than is necessary in feeding beef steers which have a good chance to grade choice.

It takes over a year in most areas to produce 1000-pound standard-to-good-grade steers from the large dairy breeds. Silage, pasture, or hay fed free choice, supplemented with 2 pounds of oil meal pellets per head daily, usually keeps them growing Legume herbage should be supplemented with a small amount of high energy feed such as corn or citrus pulp.

To make the best use of forage, dairy-beef animals should be wintered on hay alone. They will gain little weight, but will be accumulating a growth debt. Thus they owe growth which they pay when pasture becomes available in the spring. Then they will make up for the slow winter growth. During the fall, the steers should be confined and fed heavily on concentrates. During the last three months they should gain 2.5 pounds per head daily.

BULL CALVES

Bull calves to be raised for breeding purposes should be separated from the females as soon as practical after weaning. Their general feeding and management will be the same as for the heifers; the object is to keep the *animals growing as fast as possible without becoming coarse.* However, bulls will grow somewhat faster and care must be taken to be sure that ample feed and mineral supplements are available.

A light ring of cannon metal should be placed in the nose of bulls by the time that they are six months of age When the nose has healed thoroughly, it is well to begin handling the bull by the ring. When the animal is a year old, the initial ring can be replaced by a heavier one

The bull must always be handled firmly, since by nature his behavior is unpredictable and his strength, tremendous. From the first the bull must be considered a potential killer.

Since several years often are required to prove bulls, a sample of their offspring should be secured as soon as possible. Thus very limited service after most bulls reach 10 to 12 months of age seems advisable so proofs can be completed as soon as possible.

15 THE BREEDING PROGRAM

BREEDING IS NOT A CREATIVE SCIENCE, BUT A SELECTIVE ONE THE ULTImate goal is a cow whose genetic composition is ideal for optimum milk production, reproduction longevity, body type, efficiency of feed utilization and other traits that make for ease and economy of production

Since negative genetic correlations exist between some of these characteristics (*yield* and *fat content*, for example), the difficulties in developing the ideal cow are obvious Many complex characteristics of the animal are involved—for example, feed capacity appetite blood system nervous and hormonal control, enzyme systems glandular secretions and other metabolic functions as well as the interactions of all of them

THE BASIS OF HEREDITY

The body cells of the bovine, including those which make up the germinal epithelium of the ovaries and of the seminiferous tubules of the testes, contain thirty pairs of chromosomes Specific chemical areas are lined up along each chromosome These areas govern the form and function of the animal and thus are known as the genes To exert their influence they must exist in pairs one member of which is on each of the paired chromosomes Traits for which only two genes are necessary are known as unit characters

The formation of ova or sperms from the germinal epithelial tissues includes meiosis a process by which the cells are split with one member of each pair of chromosomes going to each half The products of the maturation (sperms or ova) often are referred to as sex cells or germ cells This designation is questionable however since they contain only half the original chromosomes Gamete is an accurate term used to describe either the uncombined sperm or ovum

The genes necessary for an ideal cow presumably are available Each time a gamete is formed however the genetic components are randomly assorted so that constant progress in regard to every trait is almost impossible Just which chromosome will appear in which sperm or ovum is a matter of chance Thus each time an ampule of 10 million sperms is used

or a natural service occurs, an immense number of different chromosomal arrangements is available simultaneously This is one thing which makes it possible for a trait to vary in its expression It may even disappear for a time and reappear generations later

This independent assortment of genetic factors in both sperms and eggs is likely to cause very different characteristics in full brothers and sisters, full brothers and sisters are considered to be at least 50 per cent related

Expected Progress

For these reasons it is very difficult to improve a good herd, whereas *tremendous progress is possible with mediocre animals* Progress in producing ability through genetic improvement probably is limited to about 1½ per cent annually of the producing ability of the cow population involved [4] To achieve even this percentage, the breeder must concentrate upon production, cull the low producers as fast as possible, and use only bulls from the highest producing cows

Thus an animal's value involves its own performance plus its contribution to the genetic makeup of succeeding generations Dairy cattle managers should understand many basic as well as applied aspects of inheritance *Such knowledge is necessary for planning effective breeding programs*

QUALITATIVE INHERITANCE

Qualitative inheritance involves traits which occur distinctly with no (or few) intermediates *This is in contrast to quantitative inheritance which also* will be discussed Qualitative characters are discrete A discrete character is either present or absent in an animal, with no other possibilities Thus most beef and dairy breeds are either horned or polled, Shorthorns have red, white, or roan coat colors, and Ayrshires have normal or notched ears Other characteristics which may be controlled by a single pair or at least a limited number of genes include "crampy" (neuro-muscular spasticity) and twinning There are many others [3]

A number of qualitative characters are lethal, these include such things as bulldog calves, absence of legs, brain hernia and missing leg bones Over 50 factors for dead or malformed calves are recognized

Most undesirable characters are recessive, *and thus it is possible for an* animal to be a carrier without being affected itself The actual genetic makeup of an individual is known as its *genotype*, the appearance or performance of an individual is known as the *phenotype* Thus phenotype can be defined as the outward expression of the genotype With a recessive character, an individual may appear to be normal but may transmit undesirable characters to its offspring This could cause serious trouble if the

carrier is a bull used in artificial insemination since some such animals now so used sire many thousands of calves annually

Thus in calves or cows it is important for all defects suspected of having a genetic origin to be reported Artificial insemination organizations and the purebred dairy cattle associations are compiling information as fast as possible, pedigree screening for elimination of undesirable qualitative characters may be possible soon

When individuals of known genotype (for the characteristic studied) are mated it is possible to predict the frequencies of phenotypes to be obtained If a black Holstein bull (BB) is mated to red Holstein cows (bb), all calves will be black All calves would be heterozygous (Bb), each carrying a factor for black and one for red If two of these animals are mated and have enough offspring, there will exist two phenotypes and three genotypes The genotypic ratio will be 1BB 2Bb 1bb and in appearance there will be three black animals to one red With two gene pairs involved there would be nine different genotypes and four phenotypes With just 15 to 20 gene pairs involved, the number of possible genotypes and phenotypes becomes fantastically large

QUANTITATIVE INHERITANCE

Quantitative inheritance involves traits which are continuous in nature Between the extremes in high and low milk producers some cows are producing at many different levels They do not fall into sharply defined groups The simple Mendelian ratios do not appear Although milk production and the other quantitative traits definitely are influenced genetically and the mode of inheritance is through the individual gene, so many genes and other modifying factors are involved that an entirely new concept of inheritance is required

The general function is illustrated in Figure 15 1 Sixteen possible combinations are possible in the offspring as follows

No	*Dark (100) Chromosomes*	*Light (200) Chromosomes*	*Inherited Size*
1	4	0	400
4	3	1	500
6	2	2	600
4	1	3	700
1	0	4	800

This explanation is oversimplified to make the principle clear Various complicating factors occur frequently For one thing, there may be a large number of genes for the trait concerned

The number of genetic factors involved in milk production, for example has been estimated at between 36 and 100, but many modern geneticists

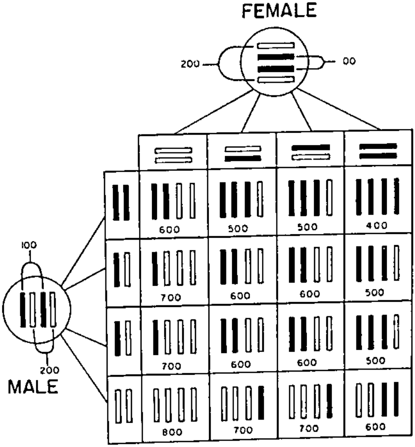

Figure 15-1. Quantitative inheritance of mature body weight.

feel that the number is probably much larger There is no way to know which of these are involved in a given individual's productive capacity

HERITABILITY

The expression of characteristics such as milk yield is influenced considerably by environment Milk production depends on feed, care, general health and the like, as well as the inherent ability of the cow to produce Phenotypic variability, therefore, can be divided into two portions, that due to inheritance and that due to environment and other factors

From the practical standpoint, the breeder is interested in what portion of the merit (or inferiority) of the parents will appear in the offspring This fraction, or per cent, is known as heritability Geneticists further describe this as heritability in the narrow sense Thus a trait which varies within the population only because of variations in environment would have a heritability of zero On the other hand, if expression of the trait depended entirely upon genetic influences, heritability would be 100 per cent

Genetic progress in a population is limited by three factors (a) the selection differential, meaning that level at which inferior individuals can be discarded and not allowed to leave offspring, (b) the multiplication rate, which is slow in dairy cattle since they have offspring less often than once

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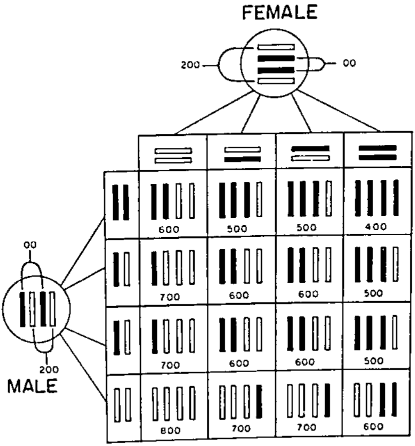

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annually, and (c) the heritability of the characteristic Other things being equal, the greatest progress can be made with characteristics which are most highly heritable

Average heritability estimates for some of the important traits are shown in Table 15-1

Effects of heritability can be demonstrated easily Suppose in a herd averaging 10,000 pounds of milk, one uses a sire whose genetic merit under the existing environmental conditions also is 10,000 pounds Assume also that the better half of the females average about 1000 pounds more than the herd average and the poorer half, 1000 pounds less Daughters of the superior half would average less than the dams, their average would lie somewhere between the average of the dams and the herd average Realizing that the dam contributes only about one half of the genes present in the offspring, and that the same sire is used on all cows in the herd, and assuming the heritability of milk yield to be 25 per cent, we find that about 12½ per cent of the phenotypic merit of the dams would appear in the offspring

Therefore, daughters of the superior dams would average 10 125 pounds of milk, the daughters of the low level dams would average 9875 pounds Of the difference of 2000 pounds in phenotypic merit in the dams a difference of only 250 pounds appears in the daughters Naturally any improvements in environment provided the daughters over that provided the dams will improve the records of all daughters They could conceiveably

Table 15 1 Heritability Estimates of Some Traits in Cattle

Trait	Heritability Estimate*
Milk yield (lbs)	0 20–0 30
Fat (%)	0 45–0 55
Solids not fat (%)	0 45–0 55
Protein (%)	0 50–0 70
Lactose (%)	0 50–0 70
Ash (%)	0 40–0 60
Longevity (years)	0 00–0 37
Persistency (%)	0 10–0 84
Gestation lengths (months)	0 30–0 50
Peak production (lbs)	0 10–0 47
Mature size (lbs)	0 34–0 79
Final type score (%)	0 15–0 30
Calving interval (months)	0 00–0 10
Service per conception (no)	0 00–0 05

*The portion of the characteristics of the parents which is likely to appear in the offspring

all average over 10,000 pounds The difference of about 250 pounds between daughters of the two groups of dams would still exist, however

It is obvious that the contribution that a single superior dam makes to a herd through her daughter is small If a son were saved and he in turn proved to be superior, the contribution would be considerably greater because his offspring could be so numerous The axiom that a sire is half the herd is at least as true today as ever Genetic progress in a dairy herd can be made to the greatest degree by using sires in which transmission of superior qualities has been proven

RECORDS OF PRODUCTION

The chance of selecting the superior animal for breeding is better than the nature of production inheritance indicates if all available information is used After individuality of the animal is considered, its pedigree should be studied in full This includes all production records to the third generation

It seems best to concentrate on selecting for total 305-day lactation yield, though persistency and maximum daily yields also are indicators of genetic merit This is because the more factors one selects for, the less progress he makes in improving total lactation yield Another important inherited characteristic is the ability to milk out quickly Under modern conditions the cow must receive less individual attention than previously, and hence it is becoming difficult to justify the selection of cows that are hard to milk even though their records for breeding, production, and reproduction may be outstanding Today's mechanized milking techniques and high labor costs make it impractical to use cattle which require special attention or have difficulty fitting into a system for mass cow handling

Many successful breeders feel that total lifetime production is an important factor Some bulls which transmit a trait for high productivity without proficient reproduction and longevity may get an undeserved reputation when only the early records of their daughters are considered Hence young bulls should be used in a limited way in any individual herd In the light of low heritability estimates for reproductive performance and longevity, it is difficult to say how much emphasis should be placed on lifetime performance In any event, use of the first lactation record alone has several advantages and practically no disadvantages

Still another consideration in the evaluation of milk production records is environment No animal can produce beyond its inherited capacity, yet poor environment will keep good inheritance from expressing itself A bull whose daughters have given him an outstanding proof possibly did so because their care and feeding was superior to that of their dams

EFFECT OF ENVIRONMENT

A scientific evaluation of the relative contributions of heredity and environment was completed recently in New Zealand It involved selection of calves from 20 low and from 20 high producing herds All were sired artifically by outstanding bulls They were assembled at the Rurakura experiment station, raised, and milked together for the first lactation

Under these conditions no significant differences between the production of the two groups was observed They then were sent back to the herds from which they came and there their production was comparable to that of the cows with which they were being milked

They were then returned to Rurakura where again there was no significant difference in their production These results were confirmed by later experiments in which pairs of identical twins were milked at the experiment station and were divided between high and low herds for other lactations

These data point up the importance of management No matter how good the breeding is, a good environment is essential to high production

This leads to an often discussed problem of which cows to cull It has been assumed that poor management by placing a ceiling on the possible production level caused the differences in ability to be obscured, i e under poor conditions cows of high genetic merit would produce no more than herd mates of poor breeding Fortunately, this does not appear to be true Probably because so many genetic factors are involved, under all but the most drastic conditions the level of a cow s production will correspond to her genetic merit relative to other cows under the same conditions

COW FAMILIES

An animal receives about half its inheritance from its dam and about half from its sire Because the male sex chromosome has fewer genes than the female sex chromosome an animal receives slightly more of its inheritance from its dam than from its sire This difference is so slight, however, for practical purposes we may assume that half of the inheritance comes from each parent

Care must be exercised in selecting both male and female breeding stock The importance of the cow side has been emphasized by a study covering many years at the Florida Station [1] Thirty-nine Jersey cows were acquired in 1901 One of these had 181 female descendants in 11 generations Her family comprised 31 per cent of the herd in 1948 Many large families can be traced to one cow and thus the importance of the distaff side is emphasized Of course only cows having a reasonable number of daughters found families

Yet the large number of descendants which are called a cow family may have little relation to the original animal or indeed to each other. This is because of the diminishing of relationship by one half with each generation Hence in the fifth generation, relationship is only 3⅛ per cent (Figure 15-2).

The use of sires across an entire herd which includes several cow families makes it likely that a family will include animals which are less closely related to each other than to other animals (such as half sisters) which are supposedly in a different cow family.

Usually the important genetic contribution of a superior cow would seem, therefore, to occur through her sons.

Age, length of each lactation, and the number of times a cow is milked each day influence the amount of milk produced. Thus for comparative purposes records must be standardized. This can be done by using the factors presented in Appendix F. Thus a 365 day record of 800 pounds of fat obtained by 4 milkings per day is equal to 675 pounds of fat yield from 3 milkings per day or 560 on twice daily milkings. Other factors can be used to compare these records to others made during standard 305 day lactations. Still other factors can be used to convert the records to what would be expected of mature cattle The term "mature equivalent" is used to describe this standard.

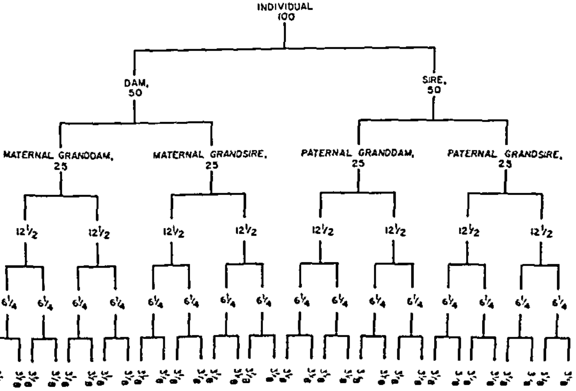

Figure 15-2. Per cent of inheritance obtained from various generations.

SYSTEMS OF BREEDING

Grading Up

Grading up (the use of purebred sires on grade herds) is a good means of improving cattle Poor herds are improved quickly, the degree of progress falling off with successive generations The amount of pure breeding in the first generation is 50 per cent, in the second 75 per cent, in the third, 87 5 per cent After six top-crosses, the herd is essentially one breed

Crossbreeding

It has not been demonstrated adequately that crossbreeding results in heterosis in milk producing ability Apparently it can cause heterosis effects of as much as 15 to 25 per cent in such characteristics as growth and birth weights The wide selection of breeding available through artificial insemination has inspired some dairy managers to practice a regular rotation of breeds for seed stock

During recent years several attempts have been made to produce superior cattle by crossing Indian and European breeds This usually has failed because of the inferiority of the milking qualities of the Indian breeds One should keep in mind that cows must produce replacements as well as milk The safest way to insure good offspring still is to take advantage of the progress which already has been made by sticking to an established breed

Outcrossing

Outcrossing involves mating animals with no common ancestors for five or more generations It helps prevent or overcome concentration of undesirable factors when related animals have been used too often

Incrossing

Incrossing is the crossing of inbred lines The value of this system has not been determined adequately but it does appear to warrant consideration

Inbreeding

Inbreeding is the mating of closely related animals This system warrants special discussion because frozen semen from bulls with proved ability to transmit desirable characteristics is available in most areas Thus there is opportunity for almost any herd owner to improve the quality of his animals through a program of carefully planned breeding Freezing prevents waste semen not needed shortly after collection can be saved Frozen semen from some outstanding bulls has been used for years

Breeding of animals which are related usually is discouraged. Use of frozen semen will help one to obtain semen from desirable bulls not related to his herd. Yet there is the probability that semen from outstanding sires will be available for indefinite periods. Dairymen will want to use the best semen available even if it has been used in his herd before. Thus the question of how to make the best of breeding possibilities and at the same time to avoid the possible pitfalls of inbreeding becomes a real problem.

Inbred animals are the offspring of parents which are more closely related than the average of the breed. Mild inbreeding often is called line-breeding. Although we consider most animals to be nonrelated, all individuals in any given species are related to some degree. This applies especially to breeds in this country, since they all descended from a relatively small number of imported animals. More than half of the American Shorthorn pedigree lines can be traced to *one* bull. All purebred Brown Swiss cattle in the United States descended from 129 cows and 21 bulls. This trend is true also for the other breeds.

Each individual has two parents, four grandparents, and so on. If there were no mating of related animals, in the thirtieth generation each individual would have over a billion ancestors. A person attempting to complete his family tree couldn't get further back than about 900 A.D. unless some ancestors appeared more than once because otherwise not much longer ago than that he would have had more ancestors than there were people on earth.

The fact that all animals within a species are at least slightly related is pointed out to show that inbreeding is not completely foreign to our animal industries. Usually specialists who produce breeding stock purposely practice inbreeding or close linebreeding to intensify desirable traits. They are careful, however, not to let it go too far because many individuals carry recessive faults which could result in decreased vigor and deformed calves.

Inbreeding has good points for any practical herd owner. Some inbreeding is almost necessary if herds are to be uniform. Selection for uniformity almost certainly means mild inbreeding. Certain individuals will be outstanding, and use of related animals is the only way to keep the influence of particularly good animals high enough to be of real value. Each generation sired by nonrelated bulls has only half the relationship of the former generation. Thus the relationship of the herd to an especially desirable individual would be only 1.56 per cent after six successive generations if completely nonrelated animals were used.

How Inbreeding Is Measured. The measure of the degree to which an animal is inbred is called the coefficient of inbreeding (CI). For an animal to be inbred, at least one ancestor must appear one or more times on both

the maternal and paternal sides of the pedigree The formula used most often for coefficient of inbreeding is one developed by Sewall Wright [6]

$$F_x = \sum[(½)^{n+n'+1}(1 + F_a)]$$

where F_x = the coefficient of inbreeding
n = the number of generations from the sire to the common ancestor
n' = the number of generations from the dam to the common ancestor
F_a = the inbreeding coefficient of the common ancestor

The dairy cattle manager can calculate the CI of an animal easily without involving himself with philosophy and mathematics of procedure

The following directions will result in an accurate calculation of the CI since they have been derived from formulas accepted and used by geneticists From the pedigree of the animal, the number of generations between the common ancestors are counted, remembering that the path must go from the paternal to maternal side or vice versa

How to Figure Inbreeding In Figure 15-3, animal A has one common ancestor D The pass from D to D involves three other animals (A B, and C) Turning to Table 15 2, we find that the CI for animal A is shown to be 12 5 per cent These data would go into Wright's formula as follows

$$F_x - (½)^3 (1 + 0) = 12\ 5\%$$

A more complicated example is given in Figure 15-4 The common ancestor of G is sire H, and he appears once on the paternal side and twice on the maternal side Thus there are two possible passes The first involves two animals (G and I) and the second involves three (G I, and J) Turning

Table 15-2 Relation of Generations per Pass to CI

Number of Animals in Each Pass	Coefficient of Inbreeding (%)
2	25 00
3	12 50
4	6 25
5	3 13
6	1 56
7	0 78
8	0 39
9	0 20
10	0 10
11	0 05

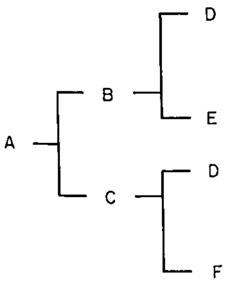

Figure 15-3. An example of inbreeding with one common ancestor appearing once on each side.

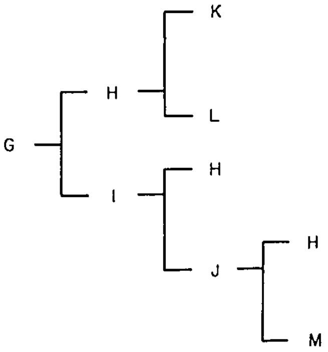

Figure 15-4. An example of inbreeding wherein the common ancestor appears twice on one side and once on the other.

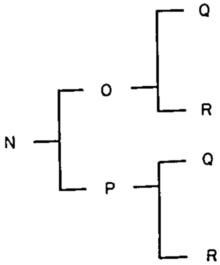

Figure 15-5. An example of inbreeding with two common ancestors.

So far we have dealt with only one common ancestor, in Figure 15-5 there are two There are two passes possible, one from Q to Q (involving O, N, and P), and one from R to R (also involving O, N, and P) From Table 15-2, we obtain 12 5 plus 12 5 which equals 25 per cent as the CI for animal N Using Wright's formula, we get

$$(\tfrac{1}{2})^3 + (\tfrac{1}{2})^3 = 12.5\% + 12.5\% = 25\%$$

One additional refinement is necessary if the common ancestor is itself inbred For example, if one looks further back in the pedigree of animal N and finds that Q is inbred, the CI for Q is determined in the same way as for any other animal Then the CI for Q is added to 100 per cent, and multiplied by the portion of the inbreeding of animal N which is due to Q For example, assume that Q is 20 per cent inbred Multiply the 12 5 per cent of the inbreeding of N due to Q (from the pass of Q to Q) by 120 per cent Thus 12 5% × 120% = 15% The inbreeding of N then is 12 5 from R plus 15 from Q or 27 5 The additional calculation corresponds to $(1 + F_a)$ in Wright's formula, and the additional inbreeding is calculated in the same way when the formula is used

Stepwise, the CI is calculated by (a) counting the number of animals involved in each pass, (b) finding the corresponding value in Table 15-2, (c) adding the values from each pass, and (d) correcting for inbreeding of the common ancestor if necessary

What Inbreeding Means from a Practical Standpoint It's easy enough to tell how much inbreeding will result from a proposed mating, but what does it mean? Other things being equal, one would expect to lose about 70 pounds of milk per lactation for each per cent of inbreeding Since there are many other variables, however, no definite rule applies universally Inbreeding coefficients help, but decisions must be based also on a thorough knowledge of the animals and a careful study of the pedigree

Owners of purebred stock sometimes breed animals as much as 40 per cent related Most dairymen probably should continue to avoid anything but very mild inbreeding unless there are special reasons (and occasionally there will be) to do otherwise Inbreeding within the dairy breeds today probably is between 5 and 10 per cent and is increasing about 0 1 per cent annually

Mating of related animals will result in some undesirable individuals Breeding back to nonrelated animals quickly overcomes most defects which crop out with the desirable attributes when mild inbreeding is used In any event careful selection is imperative

APPLYING PRINCIPLES OF BREEDING

It appears that breeding dairy cattle is largely a matter of culling low producers and selecting sires from the best cows Such selection should be

based on the following considerations (a) The ancestry should be studied in full, including records of type classification and production (b) All records should be considered on the basis of mature equivalent, two-time milking for 305 days (c) Proof should be in as large a number of herds as possible

Limited proofs can be misleading since inferior sires can have some good daughters and superior sires occasionally have inferior daughters This is illustrated by a recent proof of Winterthur Victor Star Zodiac (Table 15-3)

Table 15-3. Proof of Winterthur Victor Star Zodiac

Lactation Milk Fat Production by Groups of Daughters (lbs)	Number in Groups
700	15
650-699	21
600-649	72
550-599	121
500-549	207
450-499	292
400-449	318
350-399	295
300-349	138
250-299	84
250	30

He has 1077 daughters with 1593 records averaging 11,820 pounds of milk containing 3 75 per cent (443 pounds) of fat Thirty of their records are under 250 pounds and 15 are over 700 It appears also that daughter-dam differences and the equal parent index are no better than the simple daughter average as indicators of the sire's transmitting ability [2]

Comparison may be made best on the basis of herd mates productivity Thus sires are appraised by comparing their daughters with animals in the same herds which are similar with respect to stage of lactation, freshening dates, and age Selection of sires in artificial insemination can be done with more confidence by this than by any other method The herd-mate comparison principle needs further refinement for use in single herds (d) Some linebreeding in herd sires is desirable (e) Good health is essential (f) Type should be considered also, though most recent studies show that it has little relation to production

Hence it seems that the most rapid progress can be made by selecting for production alone If one also wants to select for type, he must expect slower improvement, according to recent U S D A findings [3]

These principles have been demonstrated successfully in 11 institutional herds in North Carolina The program involves maintenance of four

proved sires to which 75 per cent of all cows are mated. The other 25 per cent are used in proving young bulls. Changes in milk production over the years is shown in Table 15.4. Improvement in environment, partially owing to interest in the program, has doubtless been responsible for a good portion of the improvement. Separation of genetic and environmental effects has not been reported as yet.

Table 15.4 Effects of Using Proved Bulls in the Institutional Herds of North Carolina on Records Compared as Mature Equivalent 305-day Lactations with Twice Daily Milking

Year of Freshening	Number of Records	Milk (lbs)	Fat (%)	Fat (lbs)
1949	343	10,558	3.48	366
1950	554	10,971	3.49	382
1951	530	11,196	3.51	391
1952	522	11,715	3.45	403
1953	517	12,286	3.48	427
1954	588	13,035	3.52	457
1955	577	13,156	3.56	466
1956	600	13,668	3.52	480
1957	604	14,135	3.54	500
1958	630	14,600	3.63	530

Table 15.5 Effect on Production of Herd if All Daughters of Cows That Produced Less Than 400 Pounds of Milk Fat Had Been Discarded[6]

Generation	Whole Herd		Raised Herd		Discarded Herd*	
	Number	Ave. Milk Fat Yield (lbs)	Number	Ave. Milk Fat Yield (lbs)	Number	Ave. Milk Fat Yield (lbs)
1st	35	535	34	535	1	534
2nd	36	555	34	555	2	555
3rd	51	606	45	613	6	558
4th	71	673	62	677	9	645
5th	67	696	59	702	8	658
6th	71	698	63	701	8	672
7th	37	710	36	713	1	606
8th	23	720	21	726	2	649
**	391	656	354	658	37	631

*Animals with at least one female ancestor which produced less than 400 pounds of milk fat.

**Total number of animals and average milk fat yield.

Whether the calves of low producers should be culled right along with their dams is a pertinent question. Table 15-5 shows the effects of culling calves from low-producing cows when only proved sires were used. The results showed that the calves which would have been culled produced almost as well as those from the good producers. This suggests that a good management practice would be to use only proved sires and allow all offspring to complete at least one lactation.

16 BUILDINGS AND ALLIED EQUIPMENT

No AREA OF DAIRY CATTLE MANAGEMENT HAS A BETTER SCIENTIFIC FOUNDAtion than does the choice and use of housing and equipment Yet applied textbook recommendations often are confusing because each location may have special requirements

In warm regions the main structures are shade shelters and the milking barn In colder climates more emphasis is needed on insulation heating, ventilation, and facilities for keeping work outside the buildings at a minimum

PLANNING AND LOCATING THE STRUCTURES

In planning a dairy layout many decisions must be made Assistance can be obtained from commercial field men county agents and other extension personnel, and from building contractors Generally a satisfactory unit should have provisions for comfort convenience sanitation, durability and attractiveness In any event if costly mistakes are to be avoided, many points, some of which are included in the following list must be considered carefully

(1) Location of the unit should be as shown by Figure 16 1 Drainage away from the barn area must be good and the surrounding area should be free of dips and other low or swampy spots It is desirable also for the barns and surrounding lots to be protected by trees Where possible the milking facility should be located near the center of the pasture area for the obvious saving in work for man and beast

(2) A constant supply of pure water is essential

(3) The size of the herd will help determine the type and size of housing and equipment needed

(4) Climatic factors determine type of ventilation and insulation method of storing feed and bedding and type of building materials

(5) Young stock may be housed in the same building as cows or in separate structures

(6) Type of barn equipment to be installed will be determined by the type of building and personal preference

and around the main buildings This is due partly to the huge volume of materials handled (around 100 tons per cow annually) Generally, labor in handling of materials can be saved by the following suggestions

(1) When possible, let the cows go to the facility for service or material rather than taking it to them

(2) Handle large amounts rather than small batches However, automatic machines can be of smaller capacity than manually operated ones, since their running doesn't require constant attention Much of the work can be done at night when personnel and animals are out of the buildings

(3) Make the flow continuous by augers, elevators, etc Don't let the material stop then have to be lifted or loaded again before it gets to the place at which it will be used

(4) Bale, chop, grind, pellet, shell, or do whatever is necessary to make the material occupy less space and flow easily Concentrate feeds should be purchased and stored in bulk when possible

How much one can afford to spend on labor-saving devices is an individual matter A good rule of thumb for present conditions states that each $2000 properly invested reduces the labor load by 10 per cent Prices of farm equipment have increased 2½-fold in the last 20 years, but during the same time, labor costs have increased 5-fold

In new structures, one should consider storing hay as pellets, wafers, or small bales These forms of roughage require as little as one third of the storage space used for loose hay, but the storage structure must be stronger if pellets, wafers, or small bales are used The advantage is that such roughages can be moved from the field to the bin and from there to the feeding facility by a mechanized chain of operations

New buildings in this era of change should be flexible in design Present methods of feeding or storage and handling of materials are sure to be improved, but the kind and extent of future mechanization cannot be predetermined accurately Hence buildings with movable partitions and equipment are practical

Construction which permits the use of manure loaders, tractors with blades and scoops water pressure, or electric power for cleaning is sensible Smooth floors and walls which can stand frequent applications of cleaning agents also are a help to sanitation and the conservation of labor

Some of the most important points to be considered in planning for efficiency of labor are the arrangements for feeding, watering bedding, animal housing handling of milk, and cleaning of the barn and equipment Also important are the locations of the milk room feed bins, feed-mixing equipment silos water tanks hay chutes, driveways, feed alleys, doors and windows

Greater convenience means that milk output per man hour will increase

It is significant that an hour saved daily is equivalent to a month's work per year Yet the economic importance of individual attention to dairy cattle must be considered Each manager must make his own analysis To what use will the saved labor be put? He must find a market for it through more cows or other enterprises It may be possible to automate to the point that financial saving is neutralized by inefficient production, stemming from the inability to utilize new potential quickly and effectively

STORAGE SPACE

Regardless of the type of operation, a considerable store of materials must be maintained The most important of these from the standpoint of planning are feed and bedding Of course, this is an individual problem, and storage requirements vary

The amount of bedding per cow depends upon the length of the bedding period, type of barn and equipment, and the system of management For most operations, 5 to 6 pounds per head daily are required for either stall or loose barns based on 60 square feet of bedded area per cow However, if droppings are not removed daily, about 2 more pounds of bedding will be needed each day

When the requirements for feed and bedding have been determined, the space requirement can be calculated using data like those in Tables 16-1, 16-2, 16-3, and 16-4

Table 16-1 Minimal Amounts of Straw Bedding for Loose and Conventional Housing[1]

Breed	Bedded Area *per Cow* (sq ft)	Droppings Removed Daily?	Minimal Daily Straw Requirements (lbs/cow)
		Loose Housing	
Ayrshire	60	yes	5
	60	no	7
	50	yes	6
Guernsey	60	yes	6
	60	no	8
	50	yes	6–8
		Conventional Housing	
Guernsey	-	-	5
Ayrshire	-	-	6

Table 16-2 Approximate Hay Requirements per 1000-pound Cow

Type of Feeding	Feeding Period (days)	Amount of Hay Fed Per day (lbs)	Amount of Hay Fed Total (lbs)
Hay alone			
	210	25	5250
	175	25	4375
	120	25	3000
Hay and silage *			
	210	15	3150
	175	15	2625
	120	15	1800

*Hay requirements will be lower if cows get all they want of top-quality silage

Table 16-3 Approximate Concentrate Requirements for Cow in Lactation*

Feeding Rate	Milk Production Per Day (lbs)	Milk Production Per Year** (lbs)	Total Concentrate Requirements (lbs)
1 lb of Concentrate to 3 lbs of Milk			
	20	6000	2000
	25	7500	2500
	30	9000	3000
	40	12,000	4000
1 lb of Concentrate to 4 lbs of Milk			
	20	6000	1500
	25	7500	1875
	30	9000	2250
	40	12,000	3000

*If high quality roughages are self fed, concentrate requirements will be reduced considerably

**Lactation period of 300 days

LIGHTING THE BARN

Most Grade A markets have minimum requirements for lighting and there is no reason to have a questionable amount of window area, since usually it costs little or no more than solid walls Windows in the milking barn ordinarily include 1/12 as much area as the floor of the milking barn and windows in the milk rooms 1/10 the areas of their floors The window

Table 16 4 Approximate Storage Space Required for Cattle Feeds, Bedding and Cleaning Materials

Type of Material and Form of Storage	Approximate Storage Space Required per Ton (cu ft)	
	Maximum	Minimum
Loose Hay		
Shallow mows	575	450
Deep mows	450	400
Baled hay		
Loose bales	300	250
Tight bales	200	135
Chopped hay		
Long cut (2 ½ inches or more)	360	250
Short cut (less than 2 ½ inches)	250	200
Silage		
25 ft in depth	50	44
35 ft in depth	44	40
Small grain (shelled corn, wheat, barley, cowpeas, rye, milo, kaffir, corn, etc)	55	40
Oats	80	70
Mixed concentrates	40	—
Straw		
Loose	550	500
Ordinary bales	300	250
Baled wood shavings	100	—
Lime	31	—
Ground phosphate	27	—

space of the service area will depend on the design of the structures and personal preference

Placing the windows as close as possible to the ceiling will admit sun rays for a longer period each day and eliminate some breakage To be effective, windows must be clean and free of obstructions In many southern milking barns the entire upper half is open, assuring adequate use of sun radiation and eliminating the need for washing windows

Electric light generally is provided through the use of incandescent bulbs However, fluorescent lamps are satisfactory in any barn where the temperatures remain above freezing At freezing temperatures, fluorescent lights often are difficult to start As compared to incandescent lighting, fluorescent lighting provides about three times as much light per watt, but the initial and replacement costs of fluorescent tubes are greater

Lights should be located where they won t be broken easily, yet away from beams or other obstacles that might cause shadows All lighting

fixtures should be located out of the reach of cattle They have been known to try eating them Apart from the danger from glass, the electric shock can kill a cow, particularly when the bedding is wet The dust from inside broken fluorescent tubes is toxic Electric lights placed according to the following suggestions have been found satisfactory [2]

The use of 100-watt lamps throughout the farm buildings is convenient and economical, since only one size need be kept on hand for replacement

Stanchion barns should have a row of 100-watt lights centered over each alley They should be 12 to 15 feet apart over the litter alley (to provide good light at the udder) and 20 to 32 feet apart along the feed alley If there are no beams in the way, the lights should be 8 to 9 feet above the floor An even more efficient use of lamps for milking in center drive barns is provided by staggering the lamps alternately over one edge and then the other edge, of the alley

Milking barns should have the equivalent of one 100-watt light for every two or three stalls These may be placed on the wall opposite the stall and 5 to 6 feet above the floor so that they throw good light on the milking area If the wall is too far away or if ceiling lights suit particular structures better, the lights may be 7 to 7½ feet above the floor and located above the operator's head

Lights for milk rooms are especially important The Milk Ordinance and Code recommended by the United States Public Health Service calls for 10-footcandles of light at all work surfaces One 100-watt bulb over the wash vats and another at the ceiling near the center of the room generally will be sufficient

Loose housing systems also require electric lights Resting or bedded areas should have one 100 watt bulb 10 to 14 feet above the floor for each 1000 square feet of area Feeding area lights should be placed 6 to 9 feet above the feed bunks, one 100-watt bulb for each 25 feet of bunk space

Upright silos should have two lights, one for the chute and one for the silo Both should be within easy reach at the top of the chute ladder

Horizontal silos require a 100-watt bulb in a weatherproof reflector It should be mounted 12 to 15 feet above the silo entrance

Holding and service yards require large lights One 200-watt lamp in a weatherproof reflector or a 200-watt floodlamp mounted 15 or more feet above the ground is recommended With no obstructions, each light should serve 10 to 15 thousand square feet of area

Hay and feed storage areas need special consideration The light bulbs should be enclosed by a vapor-tight cover in order to reduce the danger of fire Lights should be placed near possible accident sites like ladders, chutes, or feed grinder hoppers Hay-loft lights should be high However, since they may burn out when the barn is empty, facilities for replacing them must be provided

When planning the lighting system, special attention should be given to the location of switches One should be able to snap on the light at the point of entry to any area

VENTILATION

All dairy structures must be ventilated, but this seldom is a problem except for barns in which animals are housed most of the time Any barn should have ventilation which supplies fresh air in amounts adequate for normal animal health This includes control of humidity and temperature, prevention of disease transmission, and protection from rot mold, or fungus Generally speaking, the barn structures last longer when kept dry by proper ventilation Moreover, since undesirable odors breathed in by the cows can give milk an undesirable flavor, good ventilation can be thought of as contributing to the quality of milk

Usually two exhaust fans are recommended The combined exhausting capacity should be 100 cubic feet per minute (cfm) per 1000 pounds of body weight of the animals

The reason for using fans is the removal of moisture which the animal body gives off in large amounts Since such moisture dissipation is continuous, part of the ventilation should be continuous Hence, usually one of the fans will run all the time that animals are in the barn One fourth of the total exhaust capacity is accounted for by this continuous fan

A larger fan supplies the other $\frac{3}{4}$ on a demand basis It is controlled by a thermostat which cuts in at 40° to 55°F The thermostat should be near the center of the barn at a height about even with a cow's back

Design of the air inlet system is extremely important It should admit an equal amount of air at all parts of the barn The relatively dry fresh air from outside should be pulled down the surface of the walls to dry them This is accomplished by leaving a continuous one-inch slot at the point where the ceiling joins the walls In older barns the effect can be accomplished by drilling holes $1\frac{1}{4}$ inches in diameter in the ceiling every 3 to 4 inches around the inside perimeter of the building Air also is admitted to the loft of two story barns, usually by louvers at the gable ends

The fans should be located so that they do not have to discharge into prevailing winds They should be in the warmest part of the barn and more than 8 feet from the nearest door Barn fans should have totally enclosed motors

MANURE DISPOSAL

Manure is a valuable fertilizer, but getting it from the barn to the land is one of the most serious problems on the modern day farm Mechanical barn cleaners can take most of it from closed barns which house cattle

continuously However, the trend is toward the use of water pressure for removing manure from parlors or southern milking barns

Between each shift of cows, the concrete holding areas, barns, and chutes are washed out The waste caught in holding tanks is removed frequently It can be pumped out through pipelines Irrigation pipes as small as 3 inches in diameter will carry liquid manure without clogging If allowed to stay in the holding tanks for several hours, however, the manure condenses somewhat and water must be added to assure adequate pumping action For irrigation, liquid manure usually is mixed with about 10 parts of water

Diaphragm or centrifugal pumps work well unless excessive straw or other foreign matter is included Under these conditions, liquid manure usually is not removed with irrigation equipment It can be put into a tank trailer or truck easily with as little as 13 inches of vacuum

A vacuum gauge should be installed in a place which the operator can watch during the filling operations Hence collapse of the tank because of a clogged line or other malfunction can be avoided

A float operated valve should be included to break the vacuum as the tank fills to capacity Thus the possibility that liquid might be sucked into the vacuum pump is eliminated Some modern animal operations dispose of manure from the barn by washing it into lagoons where it is covered by several feet of water Bacterial decomposition occurs rapidly without causing offensive odors or fly problems

Generally, most systems employ either stall barn or loose-housing systems where less confinement is employed In the north, stall barns usually have two stories and the second floor is used for feed storage This makes use of gravity for feed flow easy, but the cost is considerable because very heavy bracing is necessary This has become more of a problem with the introduction of pellets and small bales which are considerably heavier than equal volumes of long or chopped forage Many of the newer stall barns are of one story structure Feed and other materials can be moved mechanically in these structures by the use of augers, chains, or buckets in smaller amounts, and many are more convenient than two-story structures

STALLS

Stalls generally are one of three main types stanchion, tie, and comfort

Stanchions (Figure 16-2) may be connected so that all of the cows on one side of the barn can be released together This saves time when several shifts of cows are to be milked, as is customary in warm climates Moreover one cow at a time can be turned out if desired, and hence under some conditions stanchions are popular even though they restrict the cows considerably more than other types of stalls

Figure 16-2. A modern face-out barn with wide feed and service stanchion stall alleys. (Courtesy James Manufacturing Co.)

Figure 16-3. A face-out barn with tie stalls on one side and box stalls on the other. (Courtesy American Jersey Cattle Club.)

Tie stalls (Figure 16 3) offer cows considerably more freedom but require more labor than do stanchions Each cow must be tied and untied individually with a strap and chain to let cows in and out Because tie stalls offer more freedom to the cow than do stanchion stalls longer stall platforms are needed with tie stalls

A special type of tie stall is the inverted V stall This has a sturdy steel V shaped crossbar located just forward of the shoulder in terms of the cow in normal standing position It can be adjusted easily up and down on the upright framework and can be tilted forward or back With these adjustments the inverted V member can be positioned to allow the cow sufficient length of platform for normal standing However as she arches the back and shoulders to urinate or defecate she is forced to stand back In this way the excreta is deposited in the gutter

At the bottom of the stall there are no obstructions to the animal s movement Thus the cow is comfortable in both the standing and lying position and she can get up and lie down easily However the V member restricts the lateral movement of the animal when in the normal standing position so that she cannot easily reach into adjoining stalls

The same effect can be accomplished by the use of electric cow trainers Ordinarily they are light metal bars which are attached to a fence controller Electric trainers are adjustable for height and hence may be used in all types of stalls and for all breeds

Installations with V bars or electric trainers usually have longer stalls than otherwise would be practical because with these facilities all excreta goes into the gutters These longer stalls may prevent injuries when the animals lie down It also helps keep the cow clean makes it easier to produce high quality milk and cuts down the requirement for bedding

Comfort stalls which may be considered a special type of tie stall are designed to give the cows more freedom than is afforded by ordinary tie stalls (see Figure 16-4) Each cow is secured with a strap and a chain attached to a curb at the front Horizontal bars at the front are arranged so that the cow is forced to stand near the rear of the platform but they allow her to move forward to lie down There is nothing within the stall to restrict movement Stall space is separated by fences made of pipe and concrete

The pipes forming the front of the stall must be properly adjusted to make the cow stand back Usually the top rail serves as a vacuum line for the milking machine and the bottom rail is the water line Generally a high front manger is used

Comfort stall platforms can be about 3 inches shorter for cows of a given size than would be practical for regular tie stall platforms and electric trainers usually are recommended

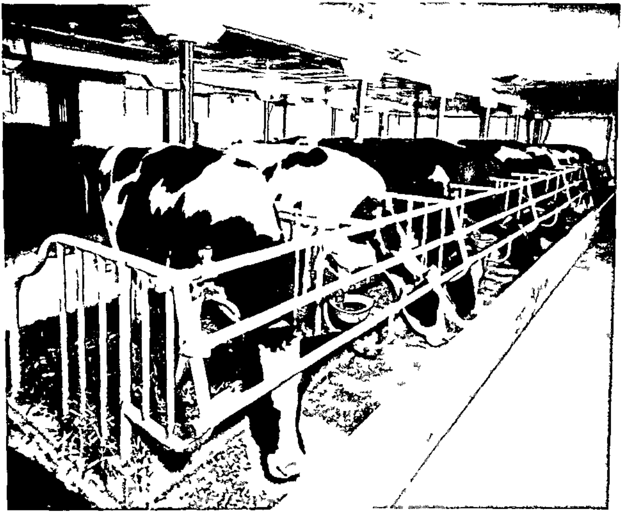

Figure 16-4. Comfort stalls allow freedom without loss of control. (Courtesy Clay Equipment Co)

One type of comfort stall has an adjustable crossbar, usually a 2 by 4 across the platform near the back When the cow is standing in this stall, the pipes in front force her to stand with her rear legs back of the crossbar Droppings and urine then fall behind the crossbar When the cow lies down, her head goes under the pipes at the front, enabling her to lie on a clean bed forward of the crossbar

The question of stall size always is a pertinent one Few barns are built with stalls which are too big Too frequently the stalls are made undersized in order to get more of them in the barn

Small stalls have caused many dairy cows to be culled as a result of teats which were damaged because of crowding Very often, chronic mastitis can be attributed to the fact that part of the udder often rests on the edge of a filthy gutter which is without bedding

To determine stall length, the distance from the shoulder to the tail setting of one of the longest cows which will use the stalls is determined For stanchions it is customary to add three inches to this, for comfort stalls, six,

and tie stalls, nine inches The width should be approximately 80 per cent of the length

Since stalls cannot be designed individually for all cows, some compromise is necessary One good method is to select two liberal sizes and use cow trainers to help keep the platforms clean

It appears that the number of udder injuries can be reduced considerably by a rubber mat for each cow housed for long periods in stalls (Figure 16-5) A good way to prevent slippage of the mats is to use metal strips

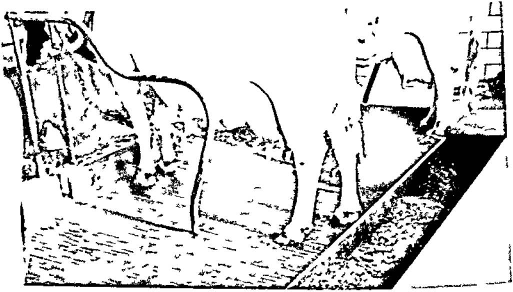

Figure 16-5. Cow Mat installation at Pennsylvania State University. (Photograph supplied by the Girton Manufacturing Co.)

on the front edge Lag screws are put through the metal and the mat and into the concrete platform

Where some bedding is available often only the rear half of the stall is covered with rubber

LOOSE HOUSING

Stall barns may be used alone or in combination with other units Some, but not all systems of loose housing management include tying each cow for individual feeding of concentrates

At least four other parts are included in most loose housing installations They are as follows the loafing area where cows rest the feeding area which is provided with facilities for hay silage greenchop (each alone or in combination) the paved lot and the milking parlor

The Loafing Barn

The loafing barn (Figure 16-6) is a resting area It should be located so that cows do not cross the bedded area to get water or to reach feed areas

Figure 16-6. A clean and dry loafing barn. (Courtesy Babson Brothers Co.)

and other parts of the system It should be on the side of the paved lot opposite the feeding area In hot climates both sides should be open In cold climates the south wall is open The long dimension in either case usually is east and west

The roof should slope away from the paved lot, or troughs and drains must be supplied Approximately 60 square feet per animal are required The area of the loafing barn may be entirely open or part of it may be partitioned off into *free stalls* The cows are not fastened but are allowed to enter or leave such stalls at will The free stall concept is somewhat new and many versions are in limited use Usually, however, a free stall consists only of two walls and one closed end, usually about 4½ feet high, within which only one cow can stand at a time These structures are very easily installed and they are inexpensive By thus affording the cows a degree of privacy without strict confinement, injuries are prevented, bedding is saved, and the animals stay cleaner than in completely open loafing barns The loafing barn should be on a well-drained site, and the pavement should slope in a way which prevents entrance of surface water Several clean-out doors should be provided

The Feeding Area

The feeding area may be covered or open (Figures 16-7 to 16-11) It may contain self-feeding or automatically unloading silos Hay may be stored in various forms—in, or close to, the feeding area Fence-line or drive through feeders may be used with all roughage supplied from trucks or self unloading wagons Molasses may be stored in tanks and feeders in the area

At least 50 square feet of feed area are needed per cow Six inches of bunk space per cow are required when self-feeding silos or hay-mows are used Two and one half feet are required for each cow if a mechanical silage bunk is used

The Paved Area

The paved area serves as a place for exercise and as a holding area for the milking parlor However, it should slope away from the milking parlor, since cows usually stand with their front feet upgrade and hence will face the parlor Slope usually is one fourth to one-half inch per foot Where possible, a drop off at one end of the pavement is provided for manure removal

Asphalt paving may be used, and for large areas, it may be more economical than concrete Asphalt must be of the type used in highway construction, and it must be installed over well compacted subsoil with a subbase at least 5-inches thick Liquid asphalt or asphalt mixed in place ordinarily is not satisfactory

If concrete is used, it should be 3 to 4 inches thick except at the perimeter where it should be approximately 8 inches to bear the load of machines entering or leaving the area Wire reinforcing usually is recommended

The Milking Parlor

Milking parlors may be of various types, but all have many requirements in common (1) A milk room should join the area in which milking is done (2) Grain should be stored close by and provision made for filling hoppers over each milking station (3) A device for measuring feed individually to each cow connects to the hopper (4) The walls are finished in ceramic tile or other easily washed material (5) Lights which illuminate the udders especially well are essential (6) Hot water must be supplied in liberal amounts (7) Artificial heat is necessary for comfort of the workers (8) Isolation pens or stalls should be provided close to the exit to hold animals for breeding or veterinary attention (9) The milking parlor must be equipped with enough floor drains to be kept clean during the milking process

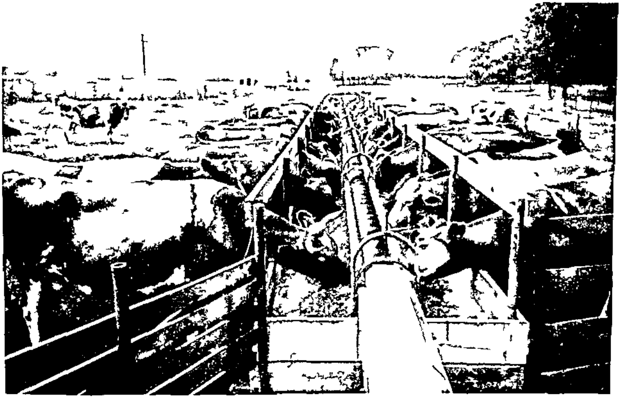

Figure 16-7 An auger silage feeder (Courtesy James Manufacturing Co.)

Figure 16-8 A drive-through feeder makes cleanliness easy with a minimum of labor (Courtesy Holstein-Friesian Association of America)

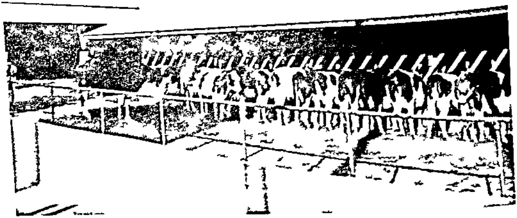

Figure 16-9 A self feeding hay barn (Courtesy Babson Brothers Co)

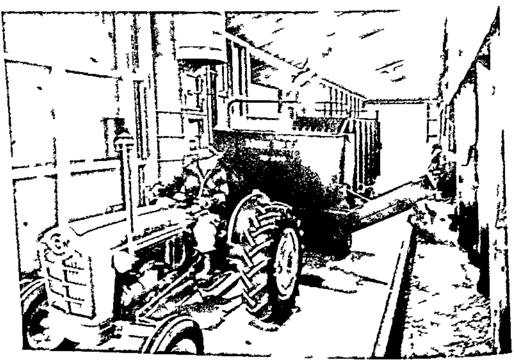

Figure 16-10 Feeding from a self unloading wagon (Courtesy New Idea Farm Equipment Co)

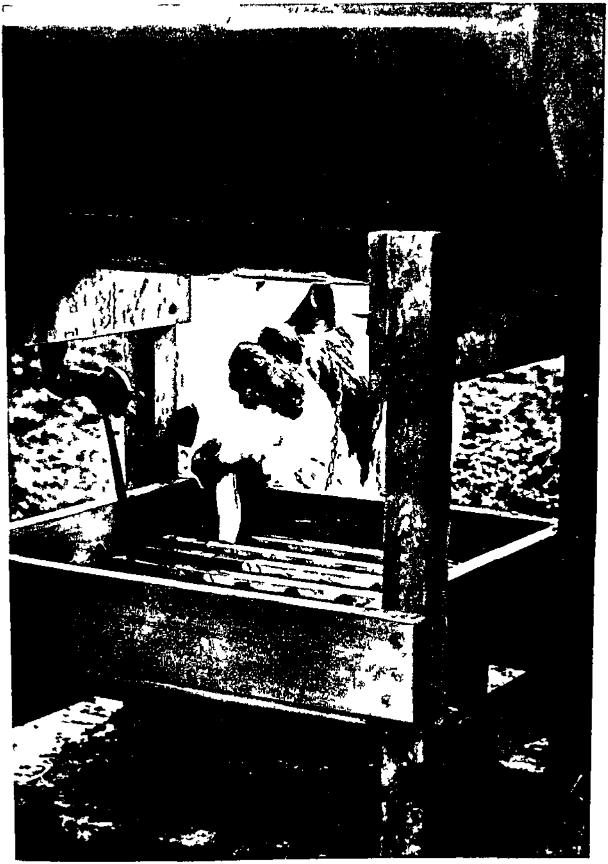

Figure 16-11. *Molasses or other liquid feeds can be supplied free-choice in the feeding area.* (Courtesy U. S. Industrial Chemicals Co.)

The term parlor does not fit any modern installation for milking cows The first milking parlors were for showing the operation to the public They served well as advertising devices but for the most part the bulk of herds using parlors were milked elsewhere because too much labor was required in the parlor Today s milking parlors are not for show but for work and more cows per man hour can be milked in any of these than in stall barns

Figure 16-12 A diagonal stall milking parlor with feeding equipment and sanitary pipelines (Courtesy Babson Brothers Co)

The two general types are the floor level and the elevated parlors The floor level parlor simply is a small stall barn through which several shifts of cows are put during each milking The longest installation of this type usually called a parlor has two rows of sixteen face out stalls and a pipe line A milking unit hangs between each two stalls during the entire operation Two men—one to wash and one to milk—are assigned to each side As soon as cows are in the stalls and fed the washer goes down the line washing every other cow The milker follows one minute behind slipping the machines on the eight washed udders

The procedure is repeated on the other eight; the milker standing between each pair of cows, slips the machine from one udder onto the other. Then the eight milked cows go out and eight more enter.

This system is employed with several variations (usually with fewer machines) in many parts of the South. Some buildings of this type which are used only for milking contain hundreds of stalls and are called milking barns because they are considered too large to be a parlor.

The other general type of parlor is the elevated type in which the cows stand 30 inches higher than the operators. The men may be in a pit, or the cows can be on a platform. Most parlors are elevated somewhat so that

Figure 16-13. Radiant heat lamps warm operators, but not the cows, in this walk-through milking parlor. (Courtesy Clay Equipment Co.)

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Figure 16-12. A diagonal stall milking parlor with feeding equipment and sanitary pipelines (Courtesy Babson Brothers Co)

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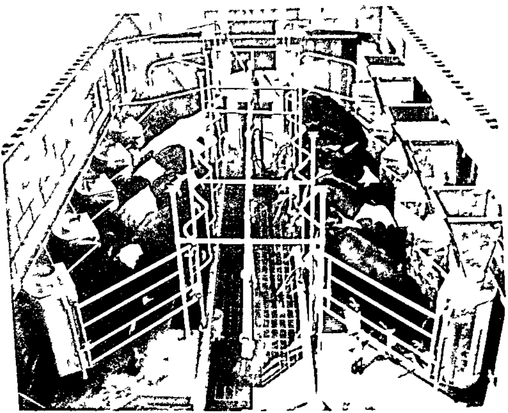


Figure 16-14 Pipelines, automatic feeding, and udders close together speed milking in herringbone parlors (Courtesy Clay Equipment Co)

cows have to walk up into them unless they can be built on the side of a hill Steps rather than ramps appear to be preferable because they are easier for the cows to use and fewer accidents occur than with ramps

The elevated systems may be U shaped around the pit they may be situated at right angles in a corner of the barn or the milking stations may form a line down each side of the pit leaving an open area at each end The U shape saves space, however it obstructs the view of the rest of the barn somewhat and visibility is important because it saves steps to check on other phases such as the cooling system water supply and the holding area

Each stall may have a separate gate at the side (Figure 16-12) or a series of stalls which accommodate batches of several animals at once may be used (Figures 16 13 16 14 and 16 15) The former allows more individual attention but the latter increases speed by handling groups of cows

The batch type parlor may be narrow keeping the cows horizontal with the pit, or an angular arrangement known as the herringbone system may be used

The latter has the advantage of putting the udders close together and hence saving steps The feed boxes are several feet from the pit, but this objection is overcome easily by placing a mirror over each one so the milker

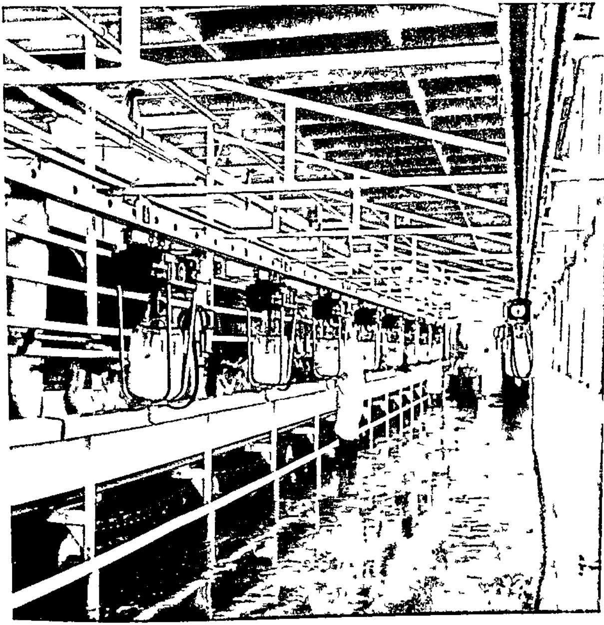


Figure 16-15. An automated system which moves cows together with all feed and equipment by means of tracks and belts. Individual production is determined from graduations on the jars. (Courtesy Deere & Co.)

Table 16-5 Typical Investment Costs and Milking Efficiency in One-Man Dairy Systems as Reported by R Rieman, U S D A

	Stanchion Barn System	Double-3 Tandem Walk-Through	Double-4 Herringbone	Double-6 Herringbone
Cow capacity (2 hrs)	60	64	86	100
No of stalls	60	6	8	12
No of milking units	3	3	4	6
Area (ft)				
Milk room	14 × 16	14 × 16	14 × 16	16 × 20
Milking parlor		10 5 × 31	16 × 21	16 × 27.5
Barn or loose housing	32 × 117	40 × 104	40 × 140	40 × 120
Costs ($)				
Building	15,000	7,926	9,898	11,000
per cow milked	250	124	115	110
Equipment	7,800	5,350	5,900	6,500
per cow milked	130	84	69	65
Total building and equipment	22,800	13,276	15,798	17,500
per cow milked	380	208	184	175
Cows per man hour	30	32	43	50
Man minutes per cow	2 00	1 88	1 40	1 20

PIPELINES AND TANKS

Labor is conserved in any setup which is integrated with pipeline and bulk tank systems The pipe which takes milk from the udder to the tank should be relatively low (below udder height if possible) and risers anywhere in the system are objectionable There are two reasons for this (1) milk goes up the risers in slugs This causes variation of the vacuum supply to the teats since vacuum is pulled behind each slug of milk (2) The second objection is agitation of the milk which is caused by air bubbles which enter as the milk is forced upward Excessive agitation can cause rancidity

Surprisingly enough rancidity occurs more frequently at temperatures just above freezing than at 38° to 40°F Lipase an enzyme which splits fat appears to be released more readily at the lower temperature

Some tanks are refrigerated on the walls but some have cooling coils in the bottom only Agitation in units with bottom cooling coils only should be delayed until the agitators are completely covered with milk This is because milk which splatters on the noncooled walls may become rancid before it is taken back into the cold milk

All bulk and pour tanks and pails are of stainless steel as are some pipelines Other pipelines are of special glass which is resistant to all chemicals used in cleaning and sanitizing Most modern pipelines of either material are cleaned in place by automatic equipment which forces detergent and sanitizing materials through under pressure

HEATING THE MILKING PARLOR

Almost all structures used exclusively for milking are drafty because it is necessary for some cows to go in at one place while others are going out at another Even in warm climates this can make milking a chilly, unpleasant job, and heating is necessary Radiation appears to be the best system of heating, since it involves electromagnetic waves which are not affected by drafts

If radiant heat lamps are focused only on the pit, the operators alone, and not the cows, will be affected A row of 250-watt lamps waist-high and others about 20 inches above the operator's head (Figure 16-14) will keep the employees warm and supply light at the same time Other radiant heaters which are operated by gas are available and may be more practical in some areas

Weighing and sampling of milk must be done occasionally in connection with all milking operations Various metering devices for use with pipelines are available, but all are in need of improvement Actual weighing is the most accurate method presently available

17 PHYSIOLOGICAL PRINCIPLES AND BUSINESS POLICY

As previous chapters attest, dairying is a complex business which requires knowledge, continuous study, an appreciation of animals, and unusual determination and skill in coordinating many activities. However, the rewards are great enough to justify the demands.

The above remarks apply especially to purebred operations. Not only are registered cattle expensive but additional expense is required for public relations and sales. Keeping purebred cattle is most easily justified economically when breeding stock is sold. One serious mistake frequently made is the purchase of entire herds by business men who have enjoyed success in other endeavors but whose dairy experience is limited to a windshield view. Dairying is a good investment for nondairymen but only if they can hire capable managers and are willing to delegate herd policy. Cows such as the one in Figure 17.1 deserve professional management.

Purebred cattle are those descended in all lines of ancestry from the foundation stock of the breed which they represent, or those which have been graded up in accordance with requirements of the respective breed associations. The Shorthorn and Red Dane breeds have grading up provisions patterned along the lines of English associations.

SELECTING A BREED

Both registered cattlemen and commercial dairymen must select definite breeds. There are five major breeds (Appendix A) of dairy cattle in America. However, it is reasonable to choose breeds other than the major ones if proper consideration is given to body size and various market factors.

Climatic Conditions

It is argued that animals representing breeds which originated in warm climates are better for the South, whereas those from cold climates are preferable for the North. Chapters 4 and 5 show that all breeds can withstand cold weather if adapted to it, and that all will suffer from excessive environmental heat (especially if they are in heavy production). Moreover, sudden downward changes in temperature often cause southern cattle

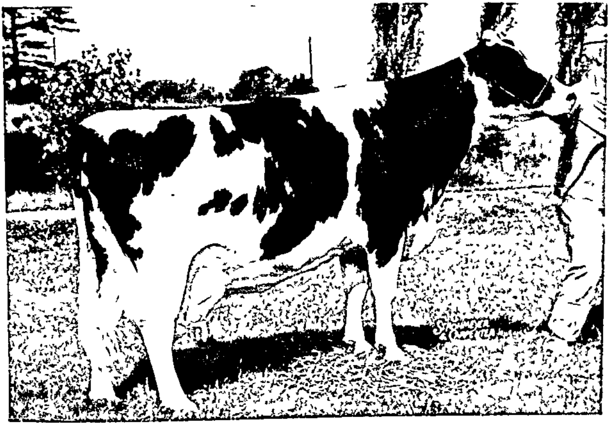


Figure 17-1. King View Francy Allegra 3393541 (VG) produced 38675 pounds of milk containing 1239 pounds of fat on twice daily milking in 365 days. (Courtesy Holstein Fresian Association of America)

to chill, and heat stress during the summer is common in most northern cattle. The fact that some breeds are slightly better adapted to certain climates than are others is a minor point

The Feed Supply

The feed supply is irrelevant in the selection of modern dairy cattle. Good feed must be supplied in adequate quantities to all high-producing cows. Although the ability of different breeds to graze varies considerably, the present prices of land and labor preclude the use of sparse pastures, even with breeds that are especially good rustlers.

Effect of Size

Large versus small breeds often is an issue. The small breeds have more body capacity for their weight and thus can eat proportionately more. Thus a greater percentage of their feed goes for productive purposes. On the other hand, their requirements for maintenance are higher on a body weight basis. These two facts tend to cancel out each other, thus there is little or no significant difference between breeds in efficiency of feed con-

version Of course, if other things are equal, large animals produce more milk than small ones Hence within breeds the large ones are preferred

Other Factors

Such things as personal preference breed in the community, source of breeding stock, and the like, are matters of business and are important There is no particular scientific method for their solution The type of market, however, is one matter which can be solved by scientific techniques

MARKETING MILK

Although the demand for fluid milk can be predicted reasonably well, milk companies must purchase about 15 per cent more than can be used as such in order to insure an adequate supply The surplus is used for the manufacture of dairy products

Obviously milk which can be bottled and sold quickly usually brings a better price than that which has to be extensively processed Hence, in the same market, for the same quality of milk, there may be several prices In many markets these different prices are calculated to a single price for each producer This is a weighted average of the various expected amounts of milk and their respective market values This value is known as the blend price

The Base Period

How much Class I milk (fluid milk to be processed, bottled and sold as such) that a particular producer can sell is predetermined by how much he makes available to the company during the base period which occurs when the supply is likely to be shortest The more milk one can produce at this time the better his blend price will be since more of his total production will be utilized as Class I Even if conditions do not warrant three or more milkings daily and very liberal feeding as a general practice such measures are likely to be a profitable aid in obtaining a substantial base for Class I milk

Cooperatives

The practice of dealing separately with a large number of producers with various sized Class I bases for milk has led to dissatisfaction in a number of markets Thus it has been advantageous to both the milk companies and the dairymen to deal cooperatively

The cooperative associations are of two general types (1) bargaining associations which do not handle milk but make all business arrangements (2) associations which process and distribute milk or assemble it for fluid

uses Some of these serve mainly as processors for surplus, others are more active as distributors

In some areas the dairymen have formed cooperatives and rented facilities from major milk companies to the mutual benefit of all The companies have an assured income, and the milk producers are able to use more of their milk as Class I

State and Federal Administration

Although these steps have helped, milk is such a perishable product and is so important to health, that many states have established milk control boards These agencies adjust prices as fairly as possible to insure a continuing supply In some areas, however, even state marketing orders have been ineffective Federal orders can be used in such cases if the dairymen want them By this means formulas are established to determine the factors which are considered in establishing the price of milk each month

Some 80 federal milk orders of various sizes and structures are in operation at present In some locations most of the production finds its way into the fluid milk market, whereas in others, half or more may be used as manufacturing milk Returns to dairymen in various parts of the nation can vary from $2 50 to over $7 00 per cwt during the same day Marketing milk continues to offer complex, perplexing, and challenging problems

At present, most milk is priced on the basis of fat test Thus a base price per cwt is set for milk of a certain per cent of fat (base fat percentage) For milk which tests higher than the base fat percentage, the price per cwt is increased a certain amount for each point (tenth of a per cent) above the base For milk with less than the base fat percentage, the price per cwt is reduced a certain amount for each point below the base The amount the price changes is the differential, and it is expressed in cents per point

FEED COST OF MILK

The energy content of milks of different fat contents varies according to the fat test plus a constant because of the amount of energy contained in the fat The energy-bearing solids not fat vary so little that their energy may be considered constant for purposes of calculating feed cost Thus the energy which can be produced by the nutrients in milk varies according to the test plus 2 66 This means for example that the difference between the energy of 4 per cent milk and two per cent milk is in the order of

$$\frac{4 + 2\ 66}{2 + 2\ 66} = \frac{6\ 66}{4\ 66} = 1\ 43$$

Dr W L Gaines[2] based calculations for feed cost on these facts plus the premise that under certain conditions the cost of producing milk will be the same percentage of the total cost regardless of the fat test Thus, if *60 per cent of the total feed* were required to produce 3 per cent milk, then *60 per cent of the total feed* also would be required for the production of 4 per cent 5 per cent, or milk of any other content of fat Thus higher fat milk would require proportionately more feed

From these facts and observations Dr Gaines concluded that the feed cost of producing whole milk as affected by the fat test varies according to the per cent of fat plus 2 66 This was true of a large number of cows observed at the Royal Veterinary and Agricultural College in Copenhagen, Denmark as interpreted by Gaines[2] (Table 17-1) Table 17-2 shows the function of a typical pricing system based on a differential of eight cents per point

The price changes 80 cents per cwt for each per cent change in fat Hence ten times the differential is the value of a pound of fat The value

Table 17 1 Data from Danish Experiments Bearing on Feed Consumption in Relation to Fat Test of the Milk

	Red Danish	Crossbred	Jersey
Number of cows	308	350	353
Average age of cows (years/months)	5y 7m	5y 10m	5y 9m
Average wt per cow	1021	1021	796
Average milk per cow per year	7934	6389	5018
Average fat test	3 60	4 28	5 34
Feed units per cow per year	3079	2748	2484
Feed units per cwt of milk*	38 8	43 0	49 5
Relative feed cost by formula**	38 8	43 0	49 6

*Danish feed unit equals 1 kg of barley or equivalent
**Feed cost proportional to percentage of fat plus 2 66

Table 17 2 Relative Value of Fat and Skim Milk Based on a Differential of Eight Cents per Point

Fat (%)	Price/cwt ($)	Value of Fat ($)	Value of Skim Milk ($)
6	6 62	4 80	1 82
5	5 82	4 00	1 82
4	5 02	3 20	1 82
3	4 22	2 40	1 82
2	3 42	1 60	1 82

of the skim milk does not vary. Considering the feed cost of whole milk (test + 2.66), the skim milk portion should be valued the same as 2.66 pounds of fat. In the example of Table 17-2, the value of the skim milk is $1.82; however, the value of 2.66 pounds of fat is 2.66 × .80 = $2.12. Thus since 2.66 pounds of fat brings more than the skim milk, one should strive for high testing milk in this particular market.

As fat becomes less important commercially, perhaps the differential will be on the basis of protein. Since protein and fat tend to increase or decrease together, a similar formula may apply. Hence, the industry may already be close to a workable protein differential. The relation of protein to fat variation needs more attention.

PLANE OF NUTRITION

The feeding standard as explained in Chapter 10 is only a guide, and the level of feeding must be determined individually by each dairyman, preferably for each cow.

At least to a point, the more feed a good cow eats the higher her production. The dairy businessman is concerned with the point at which to curtail feeding as the market varies.

The more a cow eats, the lower is the net energy per unit of feed. This results from less efficient digestion and a general decline in feed conversion just as fuel consumption per mile increases with the speed of an automobile. The greatest increase in energy loss with high nutritional planes is extra SDA. It rises from about 3 per cent on a half-maintenance ration to approximately 20 per cent on a three-maintenance ration. Thus the measures suggested in previous chapters for weather management, feed quality, conservation of adaptive energy, and the like, become increasingly important as production increases.

Biological Efficiency

Application of the animal-efficiency complex to dairy business procedures depends on the following categories. *Net Efficiency* is the percentage of feed above the maintenance requirements which is recovered in the form of output energy. *Gross Efficiency* is the percentage of the total feed (including the part used for maintenance) which is recovered in the desired products.

The maintenance requirements do not vary greatly in cows of about the same size whether they are producing at high or low levels. As shown in Figure 17-2, cow A uses about the same amount of feed for maintenance as does cow B. Cow A has a greater *net efficiency* than cow B does because of the law of diminishing returns, but what about gross efficiency? Since maintenance is included, obviously cow B has a greater gross efficiency.

Figure 17-2 Use of nutrients beyond body maintenance needs determines production efficiency

and this is closer to monetary efficiency It would be cheaper to feed cow B than two cows like A and yet the same amount of milk would be obtained

If a cow produces 10 gallons daily the second five is produced at a net efficiency lower than the first five but at a gross efficiency considerably better than would prevail if another cow s body has to be maintained to produce the second five gallons

Thus the cow as an economic unit is most efficient when producing at the maximum of which she is capable This principle is magnified by the fact that labor housing and various fixed costs are as high for low as for high producers It is recognized however that market conditions could justify operating at less than maximum production at least part of the time Most cows will produce about 80 per cent as much on high quality forage alone as with supplementary concentrates

MARKETING CATTLE

There are two general markets for purebred dairy cattle The best established breeders supply replacements and bulls for other purebred herds From these herds most of the bulls used in artifical insemination are selected Other less well established breeders supply bulls to service grade herds that use natural breeding or artificial insemination from only their own herd sires

Establishing a reputation which will induce breeders of purebred stock to seek his animals is the goal of every registered cattle dairyman Usually this requires from 10 to 20 years During this time general management is particularly important As far as the beginner is concerned variations in milk production influence net income more than 20 times as much as the breeding program Thus one must first be a good general dairyman As stated before however the sale of breeding stock is the goal of all dairymen who concentrate on purebred animals and merchandising becomes of primary importance

Not all of the costs of selling breeding stock are easily defined Items of expense include employment of more expensive labor than is necessary for operating grade herds building and maintenance of more impressive shelters and grounds and the costs of grooming and caring for cattle Other higher costs include advertising transportation and commissions Cattle

generally bring the best prices when in good flesh and when the hair is sleek and smooth Sometimes one can locate the stock he needs and save money by avoiding the expensive farms and sales Purchasing cattle is always somewhat risky, however

The reputation of the breeder is of primary importance to any decision to purchase He should be happy to be investigated through the breed association, other breeders, bankers, neighbors, or by any other means

Private Treaty

Most cattle are sold through private treaty One desiring to purchase animals goes to an area reputed to produce what he wants Contacts then can be made as previously arranged through the breed association, extension personnel, a professional cattle buyer, or all contacts can be made personally

When dealing with a reputable breeder, one can be assured of accurate information as to ancestry, production, health, breeding efficiency, and other characteristics of the animals in question Such experienced breeders can help one select the animals which he needs most They are interested in a lasting contact and usually will help one to get what he needs even at the expense of losing an immediate sale when they know where animals which meet the requirements better than their own can be located

Public Auctions

Public auctions are held frequently and if properly supervised, such sales offer a good means of buying or selling breeding stock Dispersement sales of whole herds are not unusual and are advantageous to both buyers and sellers

Unsupervised auctions are a nuisance, however, and often are considered a menace to the livestock industries because they can spread disease Health certificates may not be required, and standards for consigning animals to such sales are loosely defined to the extent that they often are used as a means of disposing of defective, diseased, low-producing, or sterile animals

A reputable consignment sale supervised by a breed association (Figure 17-3) or by a state extension service is a different matter, of course Usually the animals consigned are selected by a competent judge and the good health of all animals is assured The pedigrees are guaranteed Such sales are a source of pride for consigners and the sponsoring organizations In such cases, the work of promotion and advertising is done by the sponsor and a commission is paid on each sale The consignment sale is especially advantageous to one with only a few animals to sell

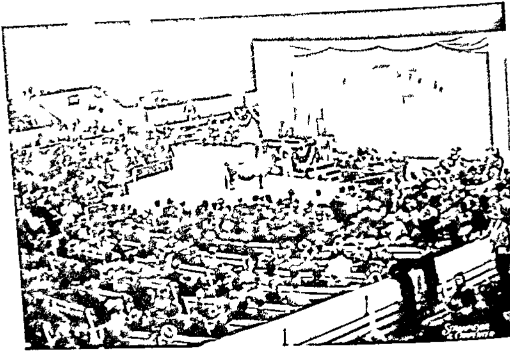


Figure 17-3 Properly run auctions inspire confidence (Courtesy American Jersey Cattle Club)

Advertising

All purebred dairymen find that advertising is essential This may be done through breed association publications and in various other news papers and magazines The official production and classification records are published in official registers by the breed associations and this is a good source of advertising

A mailing list of breeders may be maintained and printed matter in the form of a periodical newsletter sent out This would include production and type-classification information as well as pedigrees Good photographs of outstanding individuals may catch the eye of a prospect and keep him from disposing of such promotional mail An extremely good means of keeping one s name before the public is the exhibition of fine cattle at fairs shows and sales

Fitting and Showing

Fitting and showing cattle is one of the most important jobs of the pure bred business Exhibitors compete for prizes and ribbons but the experi ence and reputation gained are more important Cattle shows help train and build character in boys and girls Fairs shows and sales also provide an excellent means of publicizing individual herds and of evaluating and comparing breeding stock

When properly trained, fitted, and shown, the dairy animal is a splendid advertisement of milk and dairy products Skillful exhibits also stimulate breeding stock sales An inspiring case history is pictured in Figure 17-4 However, animals which have not benefited from proper preparation are likely to detract from the exhibit

Exhibition stock should be chosen early in the season and a realistic timetable for fitting should be adhered to strictly It seems best to select the show herd at least eight weeks in advance If possible the potential show heifers and young bulls should be segregated from the herd Show animals should be placed in the best surroundings available It is essential to provide shade and plentiful water, and to control flies and other distractions Most professional showmen keep a few extra animals in the show herd for the following reasons

(1) Young animals respond to fitting in different ways One might change his mind on a close pair after watching them for a few weeks

(2) It is best to be prepared for emergencies by carrying several animals as possible substitutes if an accident or illness should affect one of the selections

Alternate cows are selected too, especially if the first choice is due to freshen at fair time Some cows can look both their best and their worst within a two-week period either side of parturition If possible, milking cows are segregated from the herd before the show Individual attention to each animal in the show herd is a "must"

The age and size of young animals to be shown are very important Usually a large calf has an advantage in the show ring The base dates for calculating age classifications for most fairs are January 1 and July 1 as shown in Appendix I

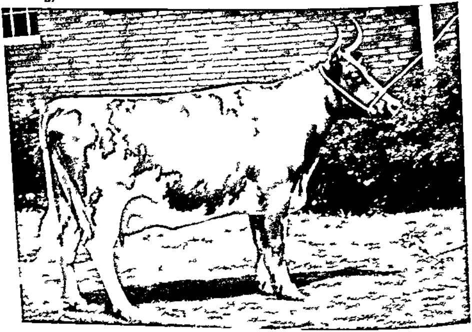
Careful fitting as shown in Figure 17-5 (pages 268–271) is essential However, showmen may clip the animals one or several days before showing, and this seems confusing to the beginner How can one tell which is right? It depends on the conditions Fitting cattle involves more than a hair cut and hoof shine If the cows have been blanketed and are smooth and glossy and if the fitter is skilled, he can do the clipping at any time—the same day as the show if he chooses

If there is any doubt, however, most of the clipping should be done long enough before showing for natural hair growth to help blend the clipped and nonclipped areas Ten days is a good limit Frequent brushing, washing, and blanketing following clipping will keep the hair short and help prevent a comedy haircut type of line between the clipped and unclipped areas Of course, touch up clipping of the head, ears, etc, may be in order at any time On the show circuit, frequent touch ups are essential

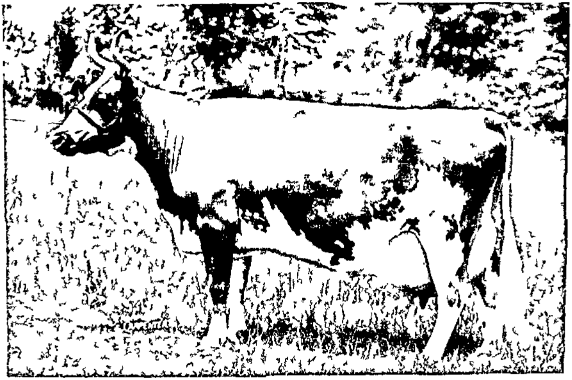
Because the hair growth of animals differ, it is difficult to make specific recommendations for clipping In general, however, the tail should be clipped

Figure 17-4 THE DEVELOPMENT OF A CHAMPION

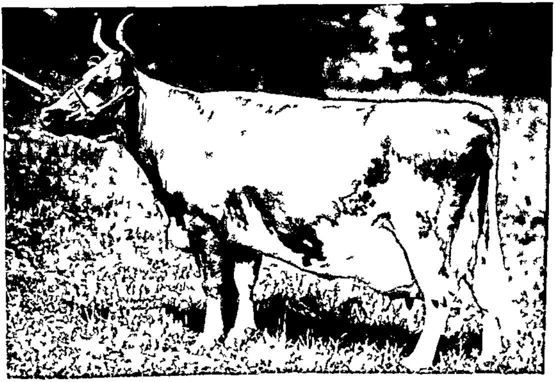
A. Photographed in 1938 at 2 years 8 months (2 y 8 m) of age and fresh only a few days Par's Red Shelia took Grand Championship honors at the Indiana State Fair Her first lactation netted 9375 M (milk) 4 89% (per cent of fat in the milk) 485 F (pounds of fat produced) 2 × (twice a day milking)



B In 1940 at 4 y 8 m of age Par's Red Shelia took top honors at the Ohio State Fair Her production remained outstanding and three years later she was classifed excellent

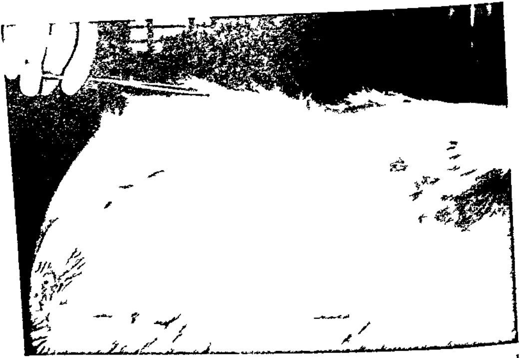


C In 1947 Shelia made a 305 day record of 18,942 M, 4 46% 844 F Her actual cumulative record by then was 122,465 M, 5365 F



D This photograph taken in 1948 shows Par's Red Shelia at 12 years of age During this year she produced 20,984 M, 4 5%, 937 F, 305 days, 2× Her total lifetime production was 165,067 M, 4 32%, 7,570 F in 3997 days

Figure 17-5 GENERAL PROCEDURES



A. Even though clipping would tend to give an unfortunate emphasis to this rough tail head careful work with the scissors helps smooth the appearance

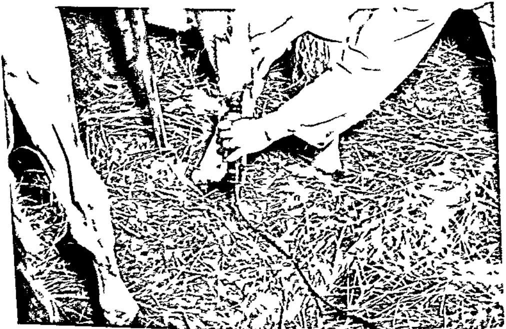
B All the hair is left on the inside of the ears of Brown Swiss

C. *The entire head is clipped*

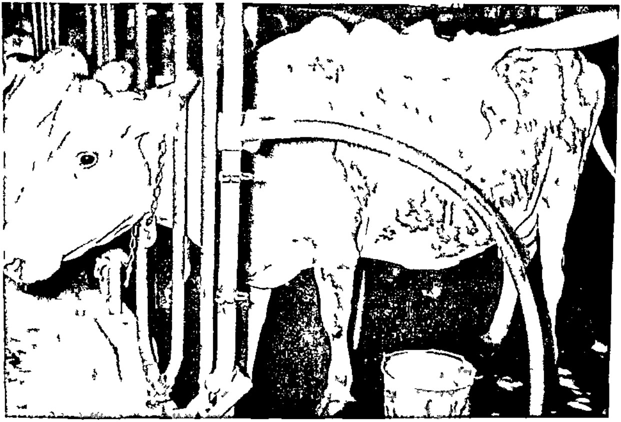
D Blending the neck and shoulder lines is not difficult if blanketing has been done

(Figure 17-5 continued)

E The hair is blended by clipping in the direction of growth



F How much of the legs to clip is an individual problem (Courtesy Sunbeam Corp)



G Washing is necessary and it is something most cows enjoy

Starting at the very top of the switch, it is clipped up to the tail head (A common mistake is to cut too high) It is best to stop at about the level of the pin bones and to blend the cut and uncut areas by clipping with the hair rather than against it Experience will teach one where to stop on different animals The small scissors will help at this point also

One common mistake is to clip along the peak of the rump of high rumped cows Many times this accentuates the condition, especially if clipping has been done less than ten days before the show A high rump must be acknowledged, though a few hairs which stand up straight may be removed with the scissors

The forehead, face and ears practically always should be clipped A ring of hair is left around the horns of Ayrshires and all of the hair is left on the inside of Brown Swiss ears Otherwise the entire head, knees, hocks, lower legs, and tail from switch up are clipped Experience is needed to decide whether it is necessary to clip the jaws, neck, and throat, some cows will benefit, others will not

Clipping hair from the udder and teats is recommended This applies especially to the long hairs which grow between the quarters and over the rear udder Considerable hair can be removed from the stomach and milk veins Here again recommendations change from cow to cow Milk veins

should be accentuated Oddly enough, some show cow fitters do this by leaving longer hairs on the veins, others by clipping closer to the body

There may be other areas (such as parts of the legs, chest, and flanks) which need attention with either the clippers or the scissors

Often there is considerable confusion regarding use of the blanket A frequent question is why not clip the animal all over Why bother using a blanket to sweat the hair out?

There are few functional sweat glands on the main part of the cow so the term is a misnomer to begin with Long, coarse hair is shed because of cellular activity The main purpose of the blanket is to control the flow of blood to areas close to the surface

Most dairymen have noticed that during the summer months cattle look smooth and sleek Blanketing show stock during warm weather often is unnecessary especially for lactating cows, because the blood comes right up to the surface to give off heat It brings nutrients to the outer layer of skin keeping the cells alive and active Dead skin and hair shed off Glands close to the surface secrete moisture and oils copiously, and these fluids keep the skin supple and the hair soft and glossy

In the winter the blood stays deeper within the body Nourishment is withdrawn from the surface Hair grows slowly and becomes coarse, since it is not shed from the thickened, hard, and dry skin and yet it is not nourished well enough to maintain a high lustre The use of the blanket helps the appearance of the whole cow by simulating to some extent conditions under which she is at her natural best Of course, clippers in the hands of a skilled fitter can help the appearance of any animal, but nature can do it better if helped with a blanket and careful attention

Blanketing is not as important in Southern states as in the North Yet in cold and rainy periods, blankets help, even in warm climates, by keeping the hair lying flat and causing secretions which give it a glossy appearance

When animals are being trucked to the exhibit, blanketing will help prevent sun and windburn, will keep the animals clean, and will help protect them against cuts and bruises

Depending on the individuals, the facilities, and the weather, cattle may be blanketed while at the fair The night before showing generally calls for blanketing

It is difficult for many dairymen to understand why a great deal of washing usually is recommended Of course, one washing just before the show will insure having clean animals, however, frequent washings throughout a period of two to three months help by removing dead skin cells, hair, and excessive secretions Thus the texture of the hair becomes fine and easily managed

Most dairy cows enjoy being washed and will be easier to handle because of it Every animal is washed at the beginning of the fitting period and at

least once more about ten days before showing This will remove accumulated dirt and grease and will allow for extra attention to the stained areas Generous amounts of water and bluing or chlorine solution are applied to stained areas Several treatments are necessary to remove some stains If stains are not treated before the animal is sent to the fair grounds, there may not be time to achieve the desired results

Moreover, it is necessary to wash the tails of all breeds and desirable to bleach the white ones One or more washings during the fitting period and just before showing usually will be adequate In addition, a good showman washes the ears This improves the appearance and aids in identification of tattooed animals The hooves are washed with a stiff brush This will help remove any foreign matter from beneath and between the toes

Combing and brushing tails often prior to showing adds considerably to the animal's appearance Braiding will curl the hair of the tail and make it more attractive Frequent brushing of the entire animal also is desirable It stimulates the flow of blood, loosens dead skin and hair, and helps increase the activity of glands and skin cells

The bottoms of the animal's hooves should be leveled She will walk more naturally and stand straighter than otherwise A crooked foot can put a strain on the whole leg, possibly making the shoulder attachments appear open The bottoms can be leveled easily with disc or belt sanders, and these tools also can be used to smooth horns Hoof and horn work can be done just as well with knives, scrapers, nippers, and rasps, but more time and considerably more skill is necessary than with sanders The toes of some dairy animals grow too long, even when they get adequate exercise Improper walking may cause depreciation in over-all appearance Excessive criticism for weak pasterns could result from poorly conditioned feet

All hoof trimming should be completed two weeks prior to showing During the intervening time the cow will recover from any temporary lameness she might have if her feet are particularly sensitive And she will get used to walking naturally again Little equipment is needed, and many things can be used as substitutes This can depend on availability or preference Hoof clippers are most commonly used, some showmen, however, use a short thick-bladed knife or a wide, flat chisel

If the animal has horns, they should be conditioned while it is young This is done by applying tension in the direction one desires the horns to grow The horns of mature animals should be sanded smooth and polished A small disc sander makes quick work of this job, and it may be left until just before the show

A good showman necessarily must be a good feeder Slight weaknesses are accentuated by underconditioning Experience is needed to attain and hold the most desirable body condition for each individual animal Dry

stock should have a high protein fitting ration combined with hay and/or silage, and beet or citrus pulp However, the normal management practices are followed with milking cows

Special feeding can help many animals Usually, hard working cows look sleek and have mellow skins This is partly because they must metabolize huge amounts of feed and thus tremendous amounts of metabolic heat are given off by bringing blood to the surface Nutritional bloom can be promoted further if a considerable part of the cow's feed is protein That part of the protein not needed directly for cellular growth and repair, and for milk promotes activity of the circulatory digestive, and secretory systems and thus tends to establish the bloom of health that is shown by clear eyes, animation supple skin and sleek silky hair Hence liberal feeding of high protein feed will help most animals Overfeeding must be avoided, of course

Overconditioning is criticized in varying degrees However most judges will be harsher in their judgment of extra weight on the younger animals and milking cows than on pregnant senior yearlings and dry cows Of course, particularly thin animals need feeds that are outstanding in digestible carbohydrates Liberal quantities of good quality but not poor quality leafy roughage helps all animals to develop depth and breadth at the midsection It is best to feed very lightly the night before the show The next day cattle will be hungry and can take on a fill of bulky nonlaxative feeds that will help emphasize good body capacity Soaked beet pulp is a good preshow filler

Special tonics for show cattle are not necessary and may contain habit forming drugs Healthy well fed animals do not need patent medicines, whereas sick cows need veterinary attention and not a cure all

Training

Unless the animal is well enough trained to be posed easily and respond quickly to the commands of the showman it may not receive proper attention from the judge (Figure 17-6)

Show animals are led with the right hand When one is ready to stop and pose his entry the strap is changed to the left hand and the showman turns around facing the animal By gentle pressure from the halter strap and the free hand a good showman can move the entry forward backward or sideways making it hold the back straight and stand squarely on all feet The careful showman always knows where the judge is and attempts to present the best view of his animal at all times When it becomes difficult to hold the animal in a desirable pose it is well to lead it out of line around and back for reposing Bulls always should be shown with a staff unless two attendants are available In this case two straps may be used

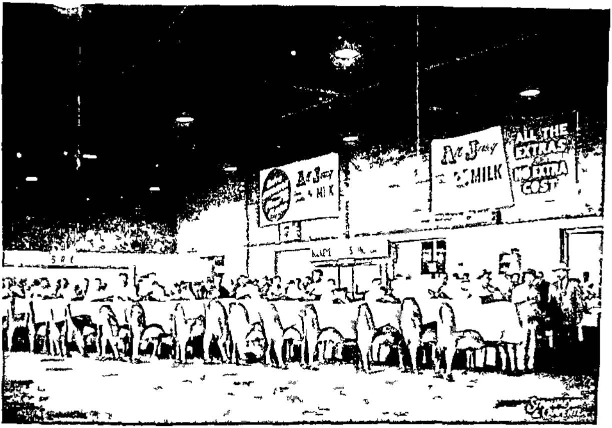


Figure 17-6 Well trained show animals are essential (Courtesy American Jersey Cattle Club)

Monetary Value of Body Type

Evaluation of body type is explained in Appendix B Various studies have been made on the effect of type on production All have shown some advantages for animals of meritorious body conformation however, since animals with the best body type generally have been kept in the best environment the value of such studies is questioned

Recently a study of animals in the same herds was completed on 45,000 Holstein cattle with official production and type classification records [3] Excellent cows averaged 480 pounds of butterfat compared to 465, 450, 435, and 420 for very good, good plus, good and fair classifications, respectively

There was a difference of 60 pounds between the production of fair and excellent cows If one should attempt to predict the performance of cattle similar to these from type scores, the chances are that the prediction would vary from actual production by more than the entire difference between fair and excellent cows This indicates that type has little to do with actual producing ability

The most highly correlated part of individual scores for type and milk production is dairy character This has been subject to criticism because most good cattle have been judged when in heavy production Naturally

they were lean and angular in appearance because of the work they were doing

There seems to be little doubt that producing ability and physical appearance of dairy cattle are related to only a small extent A recent study by U S D A personnel[1] showed that type classification was about $\frac{1}{10}$ as effective for estimating producing ability as was one record of production Also if both type and production are desired, it is necessary to breed for each as separate components

A further analysis of records showed that type had little effect on longevity This comes as a surprise It seems logical that such things as udder attachments and strength of legs would markedly affect useful life span It is logical that unsound structural development of cows should lead to a shortened life, but the present score card is not adequately designed to implicate all such individuals

These critical studies conducted on the effects of body type were necessary and commendable, and the information they provide is fundamental to a sound business approach to dairying They do not condemn a breeding program which emphasizes type, but merely point out the limitations of type as an indicator of other traits

Still, type plays a very important role in the cattle business Since appearance is important in the merchandising of automobiles, homes, clothing, and other products, it is not surprising that beautiful cattle are worth more than unattractive ones

A summary of the auctions of Holstein cattle[1] showed the price of classified animals to average $521 00 as compared to $381 00 for unclassified cattle Females with production records averaged $462 00, whereas those without records and from nontested dams averaged $381 00 It appears that classification information influenced sales prices at least as much as production records did Thus type and production both are of primary importance particularly to the breeder of purebred cattle

RECORDS

In order to maintain adequate records, some type of production testing is essential The Official Test and Herd Test systems are used exclusively by purebred herds As explained in Appendix C, however, various systems of testing are available

In addition to their value as guides to management and indicators of the efficiency of production accurate records help one to evaluate the genetic merit of cattle These records, along with pedigrees type classification scores the records of close relatives (especially offspring) together with the records of the conditions under which production was determined affect the value of cattle for breeding purposes A record of breeding and calving

dates is necessary for efficient management. Calving should be planned so that a large percentage of cows will be fresh during the base period.

Health records are particularly important because no one wants to endanger the health of his cattle by bringing a diseased or disease-carrying animal onto his farm. Moreover, dairy cattle should be tested for tuberculosis, paratuberculosis, and any other suspected disease, and should be vaccinated against brucellosis and black leg at least. Generally it is understood that cattle offered for sale are capable of breeding. One way to insure this is to have females pregnant.

The cost of feed accounts for about half the cost of running a dairy, and should be recorded carefully. Since many feed products are processed seasonally, substantial savings can be made if the entire year's supply of such items is booked during the production season.

Machinery is expensive to purchase and maintain. Very likely machines are used with greater frequency on dairy farms than the same implements would be employed on general farms. Since the average longevity figures available for machines may not apply to the dairy farm, individual records are especially important Depreciation can be handled by use of a sinking fund. Such a fund is a savings account which is designed for accumulation of the correct amount of money for replacing equipment as needed. The sinking fund shown in Table 17-3 shows how much to set aside to replace each $100.00 asset at the end of its expected useful life

Table 17-3. A Typical Sinking Fund Showing Amounts to Save at Two Practical Interest Rates to Replace a Hundred Dollar Asset at the End of Specified Times

Years	Interest Rates	
	4%	5%
1	$96.15	$95.24
2	49.02	48.78
3	32.03	31.72
4	23.55	23.20
5	18.46	18.10
6	15.08	14.70
7	12.66	12.28
8	10.85	10.47
9	9.45	9.07
10	8.33	7.95
15	4.99	4.63
20	3.35	3.02

Since interest rates and the life expectancy of equipment vary, it may be necessary at times for one to calculate his own sinking fund. This is accomplished easily by use of the following formula:

$$\text{Amount to save per year} = \text{total needed} \div \frac{(1 + i)^n - 1}{i}$$

where i = interest rate and n = number of years.

Example: A dairy manager plans to replace his tractor valued at \$5000.00 in ten years. Assuming interest at the rate of 4 per cent, his required annual deposit (the amount to save per year) would be determined by substituting this information into the formula as follows:

$$\text{Annual Deposit} = \$5000.00 \div \frac{(1 + 0.04)^{10} - 1}{0.04}$$

Although the solution can be obtained by ordinary longhand arithmetic or by logarithms, the answer in this case can be determined quickly from Table 17.3 as follows: \$8.33 × 50 = \$416.50. The answer is not exact because the values in Table 17.3 have been rounded.

The cost of labor depends largely on planning. As a rule, however, it accounts for over 30 per cent of the total expense. Since many farms are located close to large cities, taxes on dairy farms are likely to be high and to constitute an expense which must be recorded. Insurance can be minimized by maintaining the safest operation possible.

Dairying is an expensive type of farming, since a number of temporary crops may be employed to stretch the forage supply over a large part of the year. Careful soil testing and the use of recommended varieties of pasture plants help keep these costs in line with the value of the products. Records are necessary for the best decision as to what, where, and when to plant. Moreover, some dairymen must decide whether to plant at all or to purchase all of their feed, including roughage.

Other records include costs of raising calves, breeding, maintenance of buildings, and such other costs and assets as apply to business in general. Whereas a large number of items must be recorded, not all have to be considered daily, and various simple systems are satisfactory. In some states electronic systems for all computations are available at little or no cost to the farmer through extension services. Such services are available commercially almost everywhere at reasonable costs. Electronic record keeping is likely to be used widely by dairy managers in the future. Careful records and a consideration of established scientific principles are of ever increasing importance to sound business policies.

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REVIEW QUESTIONS

NOTE: The questions may be used either at the time individual chapters are being studied or as a general review after the text has been completed. In either case, corresponding reference to the Integrating Discussion (page 293) will be helpful, as it provides a review of the principles developed in the text

Chapter 1

1. What is the strongest impulse in nature? The second strongest?
2. In what way may the associative faculties of the cow be detrimental to production and reproduction.
3. Why is a domestic animal more likely to have a physiological problem than is a single-cell organism?
4. How may the hormone desoxycorticosterone help a stressed animal? How will this affect milk production?
5. Why is the normalcy which is attained during the stage of resistance considered artificial?
6. How does continued exposure to stress affect the body's store of adaptive energy?
7. *Explain the principle of homeostasis by reference to body weight.*
8. How can the conditioned reflex be useful in dairy cattle management? How may it be detrimental?

Chapter 2

1. Why is the cow a more logical animal for dairy use than is the mare?
2. What type of tissues line the various stomach compartments?
3. What advantage has an animal with a rumen over one with a well-developed coecum?
4. What general types of microorganisms are found in the rumen?
5. Why is the quality of dietary proteins not considered in feeding dairy cattle?
6. What are the functions of the reticulum?
7. What is the main difference between the anterior and posterior parts of the small intestine?
8. What are the functions of the large intestine?
9. What is the purpose of the esophageal groove? How may it create a special veterinary problem in older animals, and how may the problem be solved?
10. Why is starch digestion in the rumen an important function?

Chapter 3

1 What is a feedstuff? A nutrient?
2 What does TDN measure? What are other ways of expressing the same quality?
3 What is the nutritive ratio and why is it important?
4 How do we know that SDA is not merely energy used in digestion?
5 How does Rubner's experiment with protein utilization by the dog apply to modern dairying?
6 How did Kleiber suggest charging the system for replacement feed values? Why?
7 What are feeding standards? What is their purpose?

Chapter 4

1 What is the Van't Hoff law? How does it apply to metabolism in cold blooded species? Warm-blooded species?
2 Explain why cattle find relief from hot weather by standing in water
3 In what way does the movement of air help in keeping cattle from becoming uncomfortably hot?
4 How might radiation influence the body temperature of cattle in the open? Inside barns?
5 In what ways must air conditioning systems for cattle barns differ from conventional installations?
6 What is the zone of thermal neutrality?
7 How does humidity affect the comfort of animals during hot weather?
8 Since many physiological factors adjust automatically to help cattle adapt to hot weather why are productive processes often inhibited during the summer?
9 Why is the water supply a particularly important factor in summer comfort for dairy cattle?
10 What effect does plane of nutrition exert on heat tolerance in cattle?
11 Why is overfeeding particularly serious in the summer?

Chapter 5

1 Why do environmental temperatures affect dairy cattle differently from horses?
2 Why might the SDA of a given feed be considerably smaller during the winter than during the summer?
3 Why are cattle less easily chilled than horses? Under what conditions are they easily chilled?
4 What are the main purposes of shelter for cattle?
5 Under what conditions may cattle be more comfortable outside in the winter than when stabled?
6 How does relative humidity affect the winter comfort of cattle?
7 Since cattle are known as good cold-weather animals why do sudden cold periods often cause a drastic reduction in production of milk?
8 How can feeding practices be used to prevent winter slump in milk production?

Chapter 6

1 What are the general components of a normal bovine udder? How many glands are included?
2 How do we know that some milk proteins are not simply blood proteins which have passed through the alveolar walls?
3 What is meant by "selective filtration?"
4 How can we be sure that all milk sugar is synthesized by the tissues of the udder?
5 How does the fiber content of the ration influence the fat content of milk?
6 What determines the content in milk of Vitamins A, D, and E? Of Vitamins B Complex, K, and C?
7 What causes milk to be let down?
8 How may epinephrine interfere with normal let down of milk?
9 How do undesirable feed flavors get into milk? How can the herd manager help eliminate the problem?
10 Describe the preferred way to dry off a cow and explain why it is recommended
11 How does leaving the milking machine on too long cause udder irritation?
12 Describe the proper way to remove the milking machine from the udder

Chapter 7

1 How does stage of maturity at harvest affect nutrient content of forage?
2 How does nitrogen fertilization affect the botanical composition of legume-grass pastures?
3 How does pasture stocking rate influence yields of milk per acre? per cow?
4 In what way does pasture renovation affect the soil? the plants?
5 How can fertilization and mowing help control weeds in pastures?
6 Under what conditions may greenchopping be feasible? How may it help maintain high levels of production during hot weather?
7 What are three systems of pasturing now in common practice?
8 What managerial factors are involved in using portable electric fences? Suggest a plan for handling them
9 How can the principle of conditioning be employed in using the electric fence?

Chapter 8

1 Plants to be ensiled must contain sugar and nutrients in amounts sufficient to achieve what basic objectives?
2 For ensiling, at what stage should one harvest hay crops? corn? oats?
3 What happens to the initial oxygen which is trapped in the silo?
4 How does the osmotic pressure of the material to be ensiled influence the quality of the final product? Why?
5 What qualities should one look for in silage? In plants to use for ensiling?
6 How might diurnal variation influence the quality of silage?
7 Why is speed desirable in completing the mechanical phases of silage making?
8 What are advantages and disadvantages of partial field drying of forage which is to be ensiled?

9 If free choice of silo type and preservative is possible, how would the moisture content of the forage influence your decision?
10 How does mechanical rupture of the plant cells influence the ensiling process?
11 What is A I V silage? What is its pH? What chemical reactions are involved in making A I V silage?
12 Is use of absorptive concentrate feeds as silage preservatives particularly expensive? Why?
13 What is the most outstanding advantage of the gas-tight silo? the trench silo? plastic silo?
14 Why is venting silos important? Discuss two ways to accomplish venting sealed structures
15 What is the function of the torpedo in tub silos?
16 Discuss special problems which are pertinent to filling bunker silos
17 Using Tables 8-1 and 8-2, calculate the amount of silage remaining in an 18 × 40 foot tower silo containing 20 feet of silage if at the beginning of the season the settled silage was 37 feet deep
18 What special problem is involved in loading high moisture grain into tower silos? What materials and methods can be used to avoid the usual trouble?

Chapter 9

1 Why does drying preserve the nutrients in forage?
2 What changes, other than in moisture content, occur during curing of hay?
3 What qualities do you expect to find in good hay?
4 What factors determine the value of forage plants to be used for hay?
5 Discuss the comparative advantages of silage and hay
6 What effect does rain have on forage which is freshly cut? partially dry?
7 What types of machines are used for conditioning hay? What is the principle on which they operate?
8 Describe three different machines which can be used to harvest hay, and discuss the relative merits of each
9 In what forms may hay be stored? Discuss the relative merits of each
10 Why may grinding or pelleting improve the nutritive value of some roughages?

Chapter 10

1 What problems might arise from the use of bulky concentrates as a substitute for roughage?
2 Why are concentrate feeds necessary?
3 What special problems face the manager in using concentrates to supplement succulent pastures?
4 In what two ways is the term "concentrate" used in the feed and animal industries? Is this classification all inclusive? Explain.
5 Is urea alone a substitute for protein? Explain. Under what conditions is it feasible to include urea in concentrate mixtures?
6 Would you feed large amounts of wheat bran to cows on succulent forage? Why?

7 Why are some protein sources more valuable to cows than are others? Why is this difference less pronounced in ruminants than in monogastric species?
8 What are the common minerals used in dairy cattle feeding? What are the trace minerals?
9 What are stock foods? Under what conditions might they be harmful?
10 What is the main purpose and main limitation of feeding standards?
11 What determines whether feed mixing should be done on the farm or mixed concentrates should be purchased?
12 How many parts of oats and how many parts of a 45 per cent protein supplement would you use to make a 17 per cent protein mixture?
13 How could one cause mineral deficiencies to occur in his cattle by over-fertilizing pastures?
14 How does continued use of trace mineral supplements influence the future needs of the herd when the same pastures are used for long periods?
15 Why does copper have to be supplemented at very high levels when the feed is raised on peat soil?
16 What is a safe limit in percentage of feed which can be supplied by concentrates?

Chapter 11

1 How are practices of dairy sanitation influenced by the nature of the cow? the product?
2 Since so many good disinfectants are available, what factors other than cleanliness determine the effectiveness of the common disinfectants?
3 Why is cleanliness of primary importance to sanitation?
4 Under what conditions are submerged valves in the cups from which animals drink a threat to sanitation?
5 What is milkstone? Where is it likely to be found? How does it affect bacterial counts of milk?
6 Where in the dairy is lye recommended? What does it do? In what ways could it be harmful?
7 How do wetting agents help in dairy sanitation?
8 What is the greatest advantage to using hypochlorites? What is the greatest drawback in their use?
9 On what type of surface are the cresylic materials used? For what surfaces are they not recommended? Why?
10 What materials are used for washing the udders of cows? Discuss their relative merits
11 What are the properties of an ideal water supply?
12 What are the chemical functions which occur in cleaning?
13 What are two methods of softening water and which is preferred?
14 What use is made of acids in dairy sanitation?

Chapter 12

1 From what sources may one obtain help with animal health problems?
2 How is stress involved in a livestock health program?

3 How is sanitation related to the general health program?
4 What may be wrong when a cow is found lying down and unable to rise?
5 What metabolic derangements occur often in dairy cattle? What causes them? How are they treated?
6 What is hardware disease?
7 Why is staphylococcal mastitis thought to be on the increase?
8 How can oil help relieve a bloated animal?
9 How other than by the breeding process are diseases affecting reproduction likely to be spread?
10 In what ways might rough handling of cattle contribute to mastitis?
11 What factors make first aid to poisoned animals difficult?
12 What is the purpose of medicated feeds? Under what conditions could they be harmful?
13 How may vaccination help maintain a healthy herd? How could it be harmful?

Chapter 13

1 Discuss the effects of reproductive performance on lifetime production of milk
2 At what part of the cow s estrus cycle is it best to breed? Why?
3 Discuss the cause and effects of cystic ovaries
4 Discuss semen handling methods which prevent shocking of the sperms
5 What per cent of a normal bull ejaculate is likely to be (a) secretions from the epididymis? (b) secretions from accessory glands? (c) sperms?
6 What are properties of a good semen extender?
7 Why must milk be treated before it can be used to extend semen? What treatment is used?
8 What is the function of glycerol in frozen semen?
9 What method is recommended for artificial insemination of cattle? Why?

Chapter 14

1 Discuss prepartum feeding of pregnant cows
2 What factors are involved in determining whether one should raise his own replacements or buy them?
3 How have hand feeding methods created health problems in raising dairy calves?
4 What precautions usually are necessary to prevent digestive upsets in young calves?
5 Why is the nipple pail helpful for young calves? At what age may it be eliminated? Why?
6 How old should the calf be at weaning?
7 What properties must calf housing possess?
8 At what age can calves be turned onto pasture?
9 Discuss the raising of calves for veal mature beef and bulls for breeding purposes
10 At what age should heifers be bred?

Chapter 15

1 How does the independent assortment of genetic factors affect the predictability of any particular mating?
2 What must the breeder do in order to make the greatest improvement in milk-producing ability from his herds through breeding?
3 Explain the difference between qualitative genetics and quantitative genetics
4 Discuss the contribution that a superior dam makes to a herd through her daughters as compared as to that which is possible through a superior son
5 Discuss the effects of environment in the selection of breeding stock
6 Discuss three different systems of breeding
7 How can the records of various animals be standardized for comparison?
8 Discuss the relative merits of type and production in a dairy cattle breeding program
9 Discuss the practicality of culling the offspring of low-producing dams

Chapter 16

1 Discuss factors involved in the planning and location of dairy structures
2 What are the general characteristics of automation?
3 Discuss the effects of forms in which feed is to be stored on the type of structures used
4 Discuss lighting problems for dairy barns
5 Discuss methods for ventilating barns in which cows are housed continuously
6 Describe various methods of cleaning dairy barns
7 Describe and discuss three different types of stalls used in modern dairy barns
8 How do modern milking parlors differ from those used originally? Why has the design been changed?

Chapter 17

1 How should market conditions influence one's decision in selection of a breed?
2 Discuss the feed cost of whole milk in relation to its fat content
3 Discuss the plane of nutrition as it affects the net efficiency of milk production, as it affects the gross efficiency of milk production
4 Discuss three methods of marketing cattle
5 Why should the show herd be selected at least several weeks before animals are to be shown?
6 How does use of the blanket affect the physiology of the cow's skin?
7 Discuss feeding the show herd
8 Discuss the monetary value of body type
9 What is a sinking fund and how can it be used in dairy cattle management?

READY REFERENCE HANDBOOK

Appendix A to Appendix H

INTEGRATING DISCUSSION

NOTE Chapter references extending the principles presented herein are placed in parentheses for easy reference to the table of contents where specific page numbers are given for each main section in the book To further facilitate reference to the text, the main-section headings listed in the table of contents are carried as running heads at the top of each right hand page in the text For more specialized information, consult the index

IN MANY SPECIES THERE IS A DIGESTIVE ORGAN FOR SOAKING AND FERmentation of rough feedstuffs In the cow, this compartment, the *rumen*, is structurally placed so that it is the first compartment to receive the swallowed feed Thus the predigested feeds are subjected to further action by the entire digestive tract (Chapter 2) Hence, the cow is the economically feasible animal for the bulk of the world's milk production

Almost half the expense of dairy production is accounted for by the feed Since overhead, labor, and other fixed costs are the same in poorly and well fed herds, liberal feeding is essential On the other hand, the utilization of nutrients is subject to the law of diminishing returns, and overfeeding to the point where lactating cows gain weight is extremely wasteful The obvious feed for ruminants is leafy roughage, immature plants being the most nutritious However, if forage is to be preserved, the process should be as fast as possible, regardless of whether hay or silage is the product, because continuing metabolism can deplete nutrients even in cut plants (Chapters 7-10)

Good cattle are, of course, basic to any dairy program The proper kind of animals can be bred, though progress made through grading up is subject to diminishing returns Thus whereas a poor herd may be improved by hundreds of per cent in a few generations, very good herds can be improved only slowly by breeding *For the best results in any program of herd development, selection of breeding stock must be based mainly on milk production*, as dairy character comes closer than any other conformation factor to indicating productive merit In contradistinction, type seems to be only slightly correlated with producing ability (Chapter 15)

It is well known that production and feed records are necessary in the

evaluation of any cow (Chapter 17) Thus health and other records are vital, for in many instances of low production records there are extenuating circumstances This is graphically illustrated by the fact that approximately half the animals which leave most herds are culled because of sterility Usually, about 20 per cent of a herd is culled each year

Cattle may be housed in stall barns or in loose housing systems (Chapter 16) This involves facilities for feeding breeding, veterinary attention, resting, and care of the milk Although variations are possible, automation is essential to the success of all of them

Cattle must be handled gently according to a regular routine Otherwise, stress factors (Chapter 1) may drastically affect the functions of *production* and *reproduction* However, the milking interval need not be the same for morning and night For example, milking at 10- and 14-hour intervals seems to cause no harm as long as the milking occurs *at the same time each day* (Chapter 6)

Moreover, sudden changes in weather (Chapters 4-5) cause production losses because the cow needs time to adjust her body functions Since the cow's skin is dry, she is protected from cold weather unless blowing rains are involved However, sudden cold can cause production losses unless extra feed is supplied *Protein feeds* are especially good for providing *extra heat* because of their high SDA (Chapter 3) On the other hand, because high protein feeds cause overheating during hot weather they should be avoided at this time *Fibrous feeds* likewise cause overheating because of the heat of fermentation Moistening the skin and providing a gentle breeze is the easiest way of keeping cattle comfortable during the summer

In many areas, calves frequently can be purchased at a price less than the cost of raising replacements (Chapter 14 Chapter 17) The practice of purchasing replacements precludes the possibility of a breeding program Since usually the costs involved in raising calves are higher than they should be, they can be cut by observing a few simple principles

(1) Feed pregnant animals well The research on this point is not conclusive at present but a high protein high mineral nonfattening ration (Chapter 10 Appendix D) generally is recommended
(2) Stretch all colostrum by diluting it with skim milk (Chapter 17)
(3) Offer solid feed immediately
(4) Breed growthy heifers to calve at two years of age

Breeding may be accomplished with natural service or by means of fluid or frozen semen (Chapter 13) Certain points must be remembered with any of these systems

It is necessary to detect estrus the *heat period*, shortly after it begins The cows should be observed frequently without their knowing it, if pos-

sible Anything which causes general excitement makes estrus difficult to detect This applies especially to heifers

Most cows stay in heat about 14 hours Individuals vary from 6 to 36 hours, however, so the length of estrus that is characteristic of each cow should be recorded This will enable the dairyman to know whether to breed her at the first sign of estrus or to wait In most domestic species, the end of estrus signalizes the shedding of the egg from the ovary In the cow, however, ovulation occurs about 14 hours *after the heat period has ended* Since both the sperm and the egg will live only a few hours separately, it is important that insemination take place during the *last* part of the estrus period

Semen which is collected commercially is kept scrupulously clean and is treated to inhibit bacterial growth The inseminating equipment must be as nearly sterile as possible, since bacteria can destroy the effectiveness of the semen

Sperm cells are delicate and should never be subjected to rough handling Pulling them into the inseminating tube too quickly may break the tails off Exposure of semen to direct sunlight or to various chemicals, including soap and sulfur, will make the cells useless

Fresh semen should be stored at about 40°F and used while still at that temperature Frozen semen is stored at −110°F or −320°F Dry ice, liquid nitrogen, or a special two-stage refrigeration system is employed to maintain the low temperature The semen is thawed by being placed into crushed ice or ice water, and should be utilized as soon as it becomes liquid Based on these fundamentals, the following check list was devised for use by herd managers and technicians

(1) The herdsman should
 a Find cows in heat, determine when they should be bred, and notify the technician
 b Keep the cows which are to be bred as calm and comfortable as possible and away from the herd
 c Provide a shady place for breeding
 d Wash the external portion of the reproductive organs of the cow just before breeding
(2) The inseminator should
 a Keep semen out of direct sunlight
 b Keep equipment clean Wash equipment with a detergent (not soap), rinse in tap water, then rinse three times in distilled water, and dry in a dust-free place
 c Use 5-mm inseminating tubes for heifers and larger ones for mature cows
 d Use mineral oil or other nontoxic substance for lubrication

(3) Boil rubber equipment which touches sperm in soda water to neutralize residual sulfur
(4) Handle semen carefully to avoid physical shock

All present-day milking machines (Chapter 6) operate by a double vacuum system, and the vacuum on the teats is continuous. Pulsating vacuum in the teat cup shell causes the inflation to massage the teat. However, if any part of the machine is out of adjustment, mastitis is an almost certain consequence.

Milk is one of the most perishable foodstuffs, and sanitation (Chapter 11) probably is more important in the dairy than anywhere else. Facilities for cooling milk and keeping it clean are essential. Automation can be utilized but constant inspection by competent personnel is fundamental to adequate sanitary practices.

The cow is a rather artificial organism, having been bred for many-fold the production intended by nature (Chapter 15). It is no wonder that the balance between profitable production and financial loss is upset easily (Chapter 17). Only carefully trained personnel who enjoy animals should be allowed to work in dairies.

The udder (Chapter 6) of the cow weighs 25 to 50 pounds and may contain that much weight as milk. Thus the supporting structures of the udder are of paramount importance. The duct system is a permanent part of the udder, but the milk-secreting tissue disappears each time the cow is dry and must be regenerated during each pregnancy. Since the udder is delicate, the equipment and procedures employed in milking must be the best available. Mastitis costs American dairymen a quarter of a billion dollars annually, ant the use of antibiotics has not reduced the incidence. Careful management is necessary to keep this disease at a minimum (Chapter 12). Other diseases of dairy cattle likewise can be prevented through the cooperation of the herd manager and the veterinarian.

* * * * * * *

Almost all progress in the science of dairying has occurred during the last century. A large percentage of present knowledge of the underlying principles has developed since World War II. Information from research is accumulating in an exponential fashion, and one might look to the future with optimism. Yet many problems remain unsolved.

What milk qualities should we breed for? If the present trend continues, milk fat will become less valuable and protein more valuable.

Some researchers feel that if interactions between environment and heredity prove to be very important, it will be desirable to develop special breeds for each climate. However, improved facilities for keeping cattle

comfortable possibly will eliminate the need for this As *automation continues* its advance, this will be accompanied by changes in materials for ease of handling

It is worth noting that palatability of feeds need improvement More-over, unless a means of allowing cows to consume required amounts of feed while in the milking parlor is devised, bunk feeding by similar groups may develop The relative economies of such systems should be determined

Calf nutrition and management need further research The role of fat should be re-examined, with some emphasis on optimum fat levels in calf starters Protein quality, as well as other factors in optimum protein levels in calves, needs further work Since calfhood mortality is still too high, additional research on preventive medicine is desirable Perhaps, better immunizing agents will be developed and combined into one shot Also, heifers may be immunized against mastitis and various reproductive diseases before entering the milking herd

It is quite likely that the producing ability of dairy animals can be determined during calfhood At present udder palpation is being employed with some success, and *the breeding researchers may find a better tag* Methods for evaluating the genetic qualities of bulls at earlier ages also are needed

Chemicals and radiation for changing genetic structures have not been successful in dairy cattle Yet this possibility remains Researchers in biology have transferred genetic traits from one bacterium to others by *exchanging the desoxyribonucleic acids (DNA)*

The size of animals can perhaps be regulated by the administration of hormones Possibly, metabolic functions can be governed in this way, though to date such attempts have not been encouraging Since methods of measuring glandular secretions and functions of internal organs are at present being delineated, *the breeding programs of the future may be based* on metabolic structures as well as gross appearance and production records

It is true that ovum implants have been successful in few cows to date This does show, nevertheless, that fertilized ova can be implanted in cows *during metestrum, and the techniques certainly will be perfected* The A I technician may carry fertilized eggs rather than semen, which will mean that a herd can be changed from scrub to purebred in one generation Sex selection also seems inevitable, in laboratory animals, it already is possible to change sex ratios from the usual 50 50 to 30 70 Dairymen of the future *may raise heifer calves* from perhaps 40 per cent of their cows implanted with ova from a donor cow of their choice, fertilized by the bulls of their choice The other 60 per cent could be implanted with high quality beef zygotes Super ovulation may be induced in exceptional cows and their ova transplanted in large numbers of brood cows Thus an outstand-

ing cow's influence will not necessarily be through her sons, cow-family breeding systems will take on new meaning and progress will increase.

The allied trades and professions that serve the dairy industries must coordinate activities to keep pace with the times. Thus the geneticists should strive for development of animals with ability not only to produce well but to do so under the conditions (feed and other environmental factors) provided. As cattle are bred to use roughage efficiently, it will be incumbent upon the agronomists to supply such feeds as well as more nutritious grains.

The pest control workers must know how to control rodents and insects, but not at the cost of lost production, or undesirable flavors or harmful residues in milk. The nutritionist will need to devise rations that the feed manufacturer can formulate, mix, and deliver easily, utilizing devices developed for these purposes by engineers. Disease prevention and control programs must be devised within this general framework by veterinarians. Finally, it will be necessary for the husbandman to coordinate all these and other techniques into a sound management policy.

* * * * * * *

Since research now in progress will produce additional knowledge, the dairy cattle manager should never rely entirely on any textbook. It seems reasonable, however, to expect one who likes cows to be a successful herd manager by applying the principles explained in this volume.

The appendix material that follows gathers the most widely used standard management guides together for easy reference. Cross references to information in the text that is useful in evaluating these guides is provided with the individual appendix when pertinent.

A

THE DEVELOPMENT OF THE BREEDS

THE MAJOR BREEDS OF DAIRY CATTLE WERE DEVELOPED IN EUROPE. Cattle were brought to America on the second voyage made by Columbus. On subsequent voyages most of the early settlers brought dairy cattle from their native homes. For the most part, quality deteriorated for many years because of indiscriminate mixing with the native cattle. Between 1860 and 1880 there was considerable interest in importing carefully selected cattle from Europe. This was the foundation stock from which most of the present American purebred cattle descended. There are now five major breeds in this country.

Breed Types

Ayrshire. Ayrshire cattle were developed in the county of Ayr in southwestern Scotland. This part of the country is very hilly, and much of the land is devoted to pasture. Ayrshires have been imported into the United States since 1822. These Scottish cattle are inclined to be of stocky build. Generally, they are a mixture of red and white in color, sometimes shading to a rich mahogany. The udders are especially symmetrical and well attached to the body. The horns usually are widespreading and tend to curve upward and outward. At present, over half the Ayrshire cows in the United States are dehorned. A polled strain is increasing in popularity. On most farms, Ayrshire cattle should be expected to produce as much as 10,000 pounds of milk annually per cow. The average butterfat test is about 4.00 per cent. Mature cows weigh approximately 1050 pounds and bulls weigh 1500 to 2000 pounds. Animals of this breed tend to be somewhat nervous and high strung. They are highly animated and usually make an especially favorable appearance. They are known to be extremely good grazers.

Brown Swiss. The Brown Swiss breed was developed in the northern and eastern Alps of Switzerland. In this area the cattle are housed in valley farmsteads during the winter and pastured in the mountains during the summer. After approximately 200 Brown Swiss were imported, outbreaks of foot and mouth disease on the continent resulted in quarantine regulations which curtailed further shipments. These animals are particu-

larly strong and rugged with some tendency toward a blocky conformation which is characteristic of beef breeds The udders appear small but they are especially well attached Their production is very good often exceeding 11 000 pounds of milk about 4 per cent butterfat Colors range from gray to light or dark brown with few white markings Mature cows weigh about 1100 to 1500 pounds and bulls 1600 to 2000 pounds The animals are particularly unexcitable and move about in a sluggish manner Yet they are considered to be very good grazers

Jersey The Jersey animal originated on the island of Jersey in the English Channel Laws preventing the introduction of cattle to the island for other than immediate slaughter were passed in 1789 The first Jerseys were imported into the United States in 1850 A large portion of the Jerseys are solid fawn in color however individuals vary from light cream to dark brown and black Mixtures of white with the other colors are not unusual Pigmentation of the nose and tongue usually is black and often the switch is black Mature cows weigh 800 to 1050 pounds and the weight of bulls ranges from 1200 to 1600 pounds Good cows often produce over 9000 pounds of milk with butterfat tests of 5 3 per cent or better The Jersey is an animated type of animal though not particularly nervous This breed ranks among the best in ability to forage

Guernsey The Guernsey breed originated on the English Channel islands of Guernsey Alderney Jethro Sark and Herm Alderney was evacuated during World War II but later was restocked with cattle from Guernsey Guernseys were introduced into America in the later part of the 18th Century under the name of Alderney These animals usually are fawn and white though some solid fawn animals are seen Muzzles and tongues usually are light in color Mature cows weigh from 900 to 1400 pounds and the bulls weigh 1400 to 1900 pounds Good Guernsey cattle average about 9500 pounds or more of milk annually with a fat test of 4 8 per cent or better The milk is especially yellow in color

Holstein-Friesian The Holstein Friesian breed has been kept pure for approximately 2000 years in the lowlands of northwestern Europe The first importation of registered Holstein cattle occurred in 1861 Quarantine against foot and mouth disease prevented further importations after 1906 The Holstein Friesian name originated with the union of the Holstein Breeders Association with the Dutch Friesian Association in 1885 The term Holstein has come to be the abbreviated name for these particular animals in America All registered American Holsteins are black and white in color Some European Holsteins are red and white Mature cows weigh from 1150 to 1600 pounds and bulls from 1600 to 2400 pounds Holsteins are not known to be particularly good grazers but they do produce huge amounts of milk Good Holstein cows often produce 13 000 pounds or

more annually, the average fat test is 3 37 to 3 67 per cent Holsteins always have been popular in cheese and condensory districts, and their popularity is spreading to market milk areas, as the consumer preference for low fat milk is becoming more pronounced

Breed Associations

Imported animals may be registered if properly identified, and the records of their ancestry are provided by reference to the appropriate herd book in their native country

Animals born in the United States are eligible for registration only if both parents are registered or properly graded up for breeds having such provisions

All associations of breeds which are not of solid color require sketches or photographs of animals to be registered The owner must certify the names and registration data of the parents, the dates of breeding, birth, and the owners of the sire and dam

The registration certificate is proof of ancestry, but does not reflect individual merit Official records are necessary for individual evaluation This includes production and type classification, as well as pedigree and records of general health and management practices

Associations for promotion of registered cattle have been organized by owners of all breeds These associations keep records in a systematic way, thus assuring the accuracy of pedigrees The records are kept in what generally are called herd books

The registry organizations for the respective major breeds are as follows

Ayrshire Breeders Association, Brandon, Vermont

The Brown Swiss Cattle Breeders Association, Beloit, Wisconsin

The American Guernsey Cattle Club, Peterborough, New Hampshire

Holstein-Friesian Association of America, Brattleboro, Vermont

The American Jersey Cattle Club, Columbus, Ohio

The Purebred Dairy Cattle Association, Columbus, Ohio

B

TYPE EVALUATION

NOTE For additional information on this subject see pages 275 6)

JUDGING BODY CONFORMATION IS OF SPECIAL INTEREST TO OWNERS OF dairy cattle because type in dairy cattle is very important economically Although it is not possible to predict performance accurately from appearance animals of the accepted conformation bring premium prices

A great deal of judging as well as fitting and showing cattle is pure art Still even these phases of management can be founded on scientific principles

There are three general types of cattle judging (1) *Show ring judging* involves from two to as many as thirty animals which are placed comparatively This type of judging is used for advertising by exhibiting at fairs and shows It also offers an excellent means of training young dairymen

(2) *Classification judging* involves purebred cattle only and is sponsored by the breed associations as a tool for improvement through breeding Classification scores contribute considerably to the value of fine cattle and often afford good advertising material Considerable publicity accompanies herd classifications and all scores are recorded officially in the records of the club The designation of classes varies with the breed However for the most part 90 score points or above is considered excellent and the downward graduations usually are at a rate of about five points per class Registration certificates of animals classified as poor or the equivalent are forfeited

(3) The third general type may be called *managemental judging* This may be a combination of the first two plus any other features which one may find useful It is a part of the dairyman s system of selecting herd additions or of deciding which animals to remove The breeding program depends partly on this type of judging

In the first two cases show ring and classification judging use of the uniform score card (Tables B 1 and B 2) is essential It is helpful also in managemental judging The score card is a numerical evaluation of the various points considered in body conformation Perfection is 100 points

The student can employ the score card as a guide in evaluating various body components It is less useful to experienced judges, though the best judges must refer to it

For classification each individual is evaluated according to the score the judge feels the animal merits, considering the ideal cows of the breed as representing 100 score card points Note that most of the points involve only a few items, almost 70 points can be evaluated by looking at the udder, barrel, thighs, and withers

The score card may serve as an aid in organizing observations even for the most experienced judges Thus one may consider conformation of the animals in order General appearance is listed first, and is a logical place to start This should be judged mainly at a distance of 20 to 30 feet One can get an impression of the entire animal at that distance For comparative judging the distance must be great enough to see more than one animal at a time, otherwise comparisons would be difficult

Some points under general appearance could be very important in managemental judging Hence if the shoulders do not set smoothly against the body, the animal is more subject to injury The weakness may worsen in a relatively short time if the front legs are crooked Hence crooked legs could act as levers to pry the shoulders outward from the body Deep heels and straight pasterns are especially desirable because an animal which stands squarely on its feet needs less hoof trimming and is less likely to suffer accidental damage to the feet and legs

Dairy character is judged by the angular appearance of the cow One of the first places a producing animal loses fat deposits is from the thighs Hence a very good idea of dairy character can be had from an examination of the thigh A look at the withers, flanks, and neck will help further

Body capacity has to be judged from gross appearance Unfortunately, size is the only way to tell from appearances and this is not always reliable It does account for 20 score card points

The udder accounts for almost all of the 30 points assigned to the mammary system, many modern judges use all 30 points here The suspension system of the udder is very important If the teats tend to point to the sides, one may be reasonably sure that the medial suspensory ligament has stretched This can be confirmed by placing a hand under the floor of the udder A groove running lengthwise will be evident unless stretching has occurred

Often the front glands will protrude somewhat giving a broken appearance to an udder which may actually be sound By running the thumb and fingers across the front of the udder, one can tell quickly whether the fascia and ligaments are intact The prominence of milk veins and milk wells and

udder veins are considered to have little effect on producing ability, however, points are allotted to these features on the score card

Scar tissues, lumps, or other abnormalities often can be discovered by handling the udder It is a good idea for the managemental judge to see the udder when distended with milk If it collapses when milked, he will know that a considerable portion of the space inside is occupied by secretory tissues Udders which are about the same size before and after milking may contain excessive fat and connective tissues

Show-Ring Classes and Awards

If a calf is born after January 1 of the year shown, it is a Junior Yearling Animals born after July 1 of the year shown are Senior Yearlings Older animals usually are classified as follows bull (1 year and under 18 months), bull (18 months and under 2 years), bull (3 years and over), heifer (18 months and under 2 years, not in milk), cow (2 years but under 3), cow (3 years and under 4, cow (4 years and under 5), and cow (5 years and older)

The same animals shown in open classes may be used for group classes, or other exhibits may be made The usual group classes are as follows

Calf herd consists of one bull and two heifers all under 1 year of age

Breeder s young herd consists of 1 bull under 2 years old, 2 heifers under 1 year, and 2 heifers 1 year but under 2 years

Get of sire consists of 4 animals any age sired by 1 bull, not more than 2 bulls are included

Produce of dam consists of 2 offspring either sex, any age, from the same cow

Exhibitor s herd This class includes 1 bull 2 years or older, 1 cow 3 years or older 1 heifer 2 and under 3 years old, 1 yearling heifer, and 1 heifer under 1 year

Dairy herd Four cows over 2 years old and in milk or one may be close to calving

Senior Championship All animals 2 years and older which won in their respective classes

Junior Championship All animals under 2 years of age which won in their respective classes

Grand Championship is competition between Junior and Senior Champion ship winners

Champions are selected in both male and female classes The animal second to the Grand Champion is *Reserve Champion*

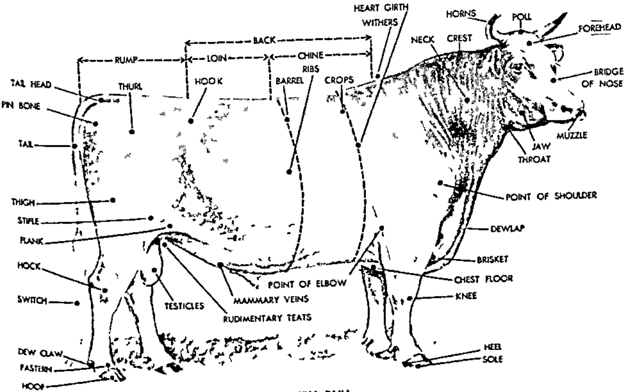
Premier Breed Award goes to the breeder whose animals win the most prizes in single classes whether animals were exhibited by him or others

Premier Exhibitor Award goes to the exhibitor winning the most prize money in single classes whether his exhibits were bred by himself or others

Table B-1. Dairy Bull Unified Score Card*

Breed characteristics should be considered in the application of this score card		Perfect Score
Order of observation		45
(1) GENERAL APPEARANCE *(Attractive individuality, with masculinity, vigor, stretch, and scale, harmonious blending of all parts, and impressive style and carriage All parts of a bull should be considered in evaluating a bull's general appearance)*		
Breed Characteristics (see page 306)	15	
Head clean cut, proportionate to body; broad muzzle with large, open nostrils; strong jaws large, bright eyes forehead, broad and moderately dished, bridge of nose straight, ears medium size and alertly carried		
Shoulder Blades set smoothly and tightly against the body	15	
Back straight and strong; loin, broad and nearly level		
Rump long wide, and nearly level from *hook bones* to *pin bones;* clean cut and free from patchiness, *thurls,* high and wide apart; *tail head,* set level with backline and free from coarseness, *tail,* slender		
Legs and Feet bone flat and strong, pasterns short and strong hocks cleanly moulded *Feet,* short, compact, and well rounded with deep heel and level sole *Fore legs,* medium in length, straight and wide apart, squarely placed *Hind legs,* nearly perpendicular from hock to pastern from the side view, and straight from the rear view	15	
(2) DAIRY CHARACTER *(Angularity and general openness, without weakness; freedom from coarseness)*		30
Neck long, with medium crest and blending smoothly into shoulders, clean cut throat, dewlap, and brisket *Withers,* sharp *Ribs,* wide apart, rib bones wide, flat, and long *Flanks,* deep and refined *Thighs,* incurving to flat, and wide apart from the rear view *Skin,* loose and pliable		
(3) BODY CAPACITY *(Relatively large in proportion to size of animal, providing ample capacity, strength, and vigor)*		25
Barrel strongly supported, long and deep; ribs highly and widely sprung; depth and width of barrel tending to increase toward rear	12	
Heart Girth large and deep, with well sprung fore ribs blending into the shoulders; full crops full at elbows wide chest floor	13	
Total		100

Subscores are not used in breed type classification



PARTS OF A DAIRY BULL

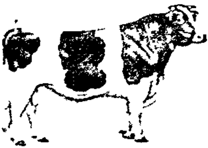
(continued)

*Courtesy Purebred Dairy Cattle Association

IDEAL AYRSHIRE BULL

IDEAL BROWN-SWISS BULL

IDEAL GUERNSEY BULL



IDEAL HOLSTEIN-FRIESIAN BULL

IDEAL JERSEY BULL

BREED CHARACTERISTICS

AYRSHIRE

Strong and robust, showing constitution and vigor, symmetry, style and balance throughout.

Color. Light to deep cherry red, mahogany brown, or a combination of any of these colors with white, or white alone; distinctive red and white markings preferred; black or brindle objectionable. Red markings usually a deeper shade on the bull than on the cow.

Size. A mature bull in breeding condition should weigh at least 1850 lbs.

Horns. Inclining upward, medium size, medium length and tapered toward tips. No discrimination for absence of horns.

BROWN SWISS

Strong and vigorous, but not coarse. Size and ruggedness with quality desired. Extreme refinement undesirable.

Color. Solid brown preferred, varying from light to very dark. White or off-color spots are objectionable. Males with any white or off-color markings, or with white core in switch do not meet color standards of the Brown Swiss breed and shall be so designated when registered. Pink noses and light streaks up the side of the face objectionable.

Size. The minimum weight for mature bulls should be about 2000 lbs.

Horns. Tending to incline slightly forward, of medium length, not coarse, tapering toward tips. Polled animals not barred from registry. No discrimination for absence of horns.

GUERNSEY

Size, strength and vigor, with quality and character desired.

Color. A shade of fawn with white markings clearly defined. Skin should show golden yellow pigmentation. When other points are equal, a clear (buff) muzzle will be favored over a smoky or black muzzle.

Size. A mature bull in breeding condition should weigh about 1700 lbs

Horns. No discrimination for absence of horns.

HOLSTEIN

Strong masculine qualities in an alert bull possessing Holstein size and vigor.

Color. Black and white markings clearly defined. Color markings that bar registry are solid black, solid white, black in switch, black belly, black encircling leg touching hoof head, black from hoof to knee or hock, black and white intermixed to give color other than distinct black and white.

Size. A mature bull in breeding condition should weigh at least 2200 lbs

Horns. No discrimination for absence of horns.

JERSEY

Strong and vigorous. Size and ruggedness with quality desired.

Color. A shade of fawn, with or without white markings.

Size. A mature bull in breeding condition should weigh about 1500 lbs.

Horns. Incurving, refined, medium length and tapering toward tips. No discrimination for absence of horns.

EVALUATION OF DEFECTS

In a show ring, disqualification means that the animal is not eligible to win a prize. Any disqualified animal is not eligible to be shown in the group classes. In slight to serious discrimination, the degree of seriousness shall be determined by the judge.

EYES

(1) Total blindness: *Disqualification*

(2) Blindness in one eye: *Slight discrimination*

(3) Cross-eyes: *Slight discrimination*

WRY FACE

Slight to serious discrimination

CROPPED EARS

Slight discrimination.

PARROT JAW

Slight to serious discrimination

SHOULDERS

Winged. *Slight to serious discrimination*

TAIL SETTING

Wry tail or other abnormal tail settings: *Slight to serious discrimination.*

LEGS AND FEET

(1) Lameness—apparently permanent and interfering with normal function: *Disqualification.*

—apparently temporary and not affecting normal function: *Slight discrimination*

(2) Bucked knees: *Slight to serious discrimination.*

(3) Evidence of arthritis, crampy hind leg: *Serious discrimination.*

(4) Boggy hocks: *Slight to serious discrimination.*

LACK OF SIZE

Slight to serious discrimination.

TESTICLES

Bull with one testicle or with abnormal testicles: *Disqualification*

OVERCONDITIONED

Slight to serious discrimination.

TEMPORARY OR MINOR INJURIES

Blemishes or injuries of a temporary character not affecting animal's usefulness: *Slight discrimination.*

EVIDENCE OF SHARP PRACTICE

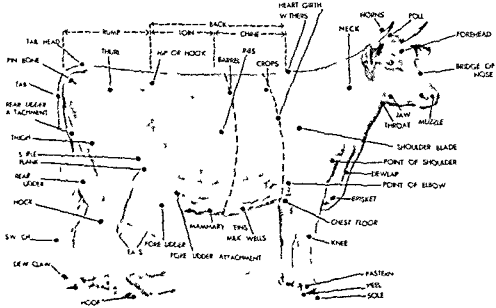
Animals showing signs of having been operated upon or tampered with for the purpose of concealing faults in conformation, or with intent to deceive relative to the animal's soundness: *Disqualification*

Table B-2. Dairy Cow Unified Score Card*

Breed characteristics should be considered in the application of the score card		Perfect Score
Order of observation		
(1) GENERAL APPEARANCE		30
(Attractive individuality with femininity, vigor, stretch, scale, harmonious blending of all parts, and impressive style and carriage. All parts of a cow should be considered in a cow's general appearance)	15	
Breed Characteristics—(see pages 309-10)		
Head—clean cut, proportionate to body; broad muzzle with large, open nostrils; strong jaws; large, bright eyes; forehead, broad and moderately dished; bridge of nose straight; ears medium size and alertly carried		
Shoulder blades—set smoothly and tightly against the body		
Back—straight and strong; loin, broad and nearly level		

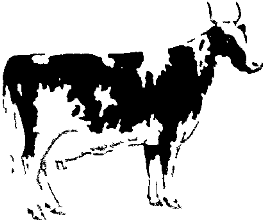
Table B 2 (Continued)

Breed characteristics should be considered in the application of this score card		Perfect Score
Rump—long, wide and nearly level from *Hook Bones* to *Pin Bones*, clean cut and free from patchiness; *thurls* high and wide apart; *tail head* set level with backline and free from coarseness; *tail* slender.		
Legs and Feet—bone flat and strong; *pasterns* short and strong; *hocks* cleanly moulded; *feet* short, compact and well rounded with deep heel and level sole. *Fore Legs* medium in length, straight, wide apart and squarely placed. *Hind Legs* nearly perpendicular from hock to pastern, from the side view, and straight from the rear view	10	
(2) DAIRY CHARACTER		20
(Evidence of milking ability, angularity and general openness without weakness; freedom from coarseness giving due regard to period of lactation)		
Neck—long, lean and blending smoothly into shoulders, clean cut throat, dewlap and brisket. *Withers* sharp. *Ribs* wide apart, rib bones wide, flat and long. *Flanks* deep and refined. *Thighs* incurving to flat and wide apart from the rear view, providing ample room for the udder and its rear attachment. *Skin* loose and pliable	20	
(3) BODY CAPACITY		20
(Relatively large in proportion to size of animal, providing ample capacity, strength and vigor)		
Barrel—strongly supported, long and deep; ribs highly and widely sprung; depth and width of barrel tending to increase toward rear	10	
Heart Girth—large and deep with well sprung fore ribs blending into the shoulders; full crops; full at elbows; wide chest floor	10	
(4) MAMMARY SYSTEM		30
(A strongly attached, well balanced, capacious udder of fine texture indicating heavy production and a long period of usefulness)		
Udder—symmetrical, moderately long, wide and deep, strongly attached, showing *moderate cleavage* between halves, no quartering on sides; soft, pliable and well collapsed after milking; quarters evenly balanced	10	
Fore udder—moderate length, uniform width from front to rear and strongly attached	6	
Rear udder—high, wide, slightly rounded, fairly uniform width from top to floor and strongly attached	7	
Teats—uniform size of medium length and diameter, cylindrical, squarely placed under each quarter, plumb and well spaced from side and rear views	5	
Mammary Veins—large, long, tortuous, branching	2	
"Because of the natural undeveloped mammary system in heifer calves and yearlings, less emphasis is placed on mammary system and more on general appearance, dairy character and body capacity. A slight to serious discrimination applies to overdeveloped, fatty udders in heifer calves and yearlings."		
Subscores are not used in breed type classification		
Total		100

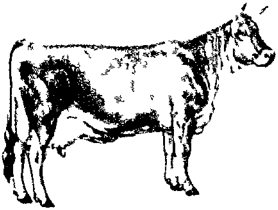


PARTS OF A DAIRY COW

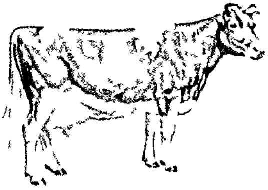
* Courtesy Purebred Dairy Cattle Association.



IDEAL AYRSHIRE COW

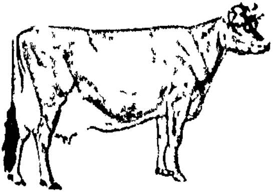


IDEAL BROWN SWISS COW



IDEAL GUERNSEY COW

IDEAL HOLSTEIN FRIESIAN COW



IDEAL JERSEY COW

BREED CHARACTERISTICS

AYRSHIRE

Strong and robust showing constitution and vigor symmetry style and balance throughout and characterized by strongly attached evenly balanced well-shaped udder

Color—Light to deep cherry red mahogany brown or a combination of any of these colors with white or white alone d stinctive red and white markings preferred black or brindle objectionable.

Size—A mature cow in milk should weigh at least 1200 lbs.

Horns—Inclining upward refined medium length and tapered toward t ps. No d scrimination for absence of horns.

Table B-2. (Continued)

Breed Characteristics (continued)

BROWN SWISS

Strong and vigorous, but not coarse. Size and ruggedness with quality desired. Extreme refinement undesirable.

Color—Solid brown varying from very light to dark. White or off-color spots objectionable. Females with any white or off-color markings above the underside of the body or with white core in switch do not meet color standards of the Brown Swiss breed, and shall be so designated when registered. Pink noses and light streaks up the side of the face objectionable.

Size—The minimum weight for mature cows should be about 1400 lbs.

Horns—Incurving and inclining slightly up. Of medium length, lacking coarseness, tapering toward tips. Polled animals not barred from registry. No discrimination for absence of horns.

GUERNSEY

Size and strength with quality and character desired.

Color—A shade of fawn with white markings clearly defined. Skin should show golden yellow pigmentation. When other points are equal, a clear (buff) muzzle will be favored over a smoky or black muzzle. A bright golden yellow pigmentation on the nose, around the eyes, in the ears, in the escutcheon, around the udder and at the point of tail is favored.

Size—A mature cow in milk should weigh at least 1100 lbs. "In milk" means normal condition after having been in milk from 3 to 6 months.

Horns—No discrimination for absence of horns.

HOLSTEIN

Rugged feminine qualities in an alert cow possessing Holstein size and vigor.

Color—Black and white markings clearly defined. Color markings that bar registry are solid black, solid white, black in switch, black belly, black encircling leg touching hoof head, black from hoof to knee or hock, black and white intermixed to give color other than distinct black and white.

Size—A mature cow in milk should weigh at least 1500 lbs.

Horns—No discrimination for absence of horns.

JERSEY

Sharpness with strength indicating productive efficiency.

Color—A shade of fawn with or without white markings.

Size—A mature cow in milk should weigh about 1000 lbs.

Horns—Incurving, refined, medium length and tapering toward tips. No discrimination for absence of horns.

EVALUATION OF DEFECTS

In a show ring disqualification means that the animal is not eligible to win a prize. Any disqualified animal is not eligible to be shown in the group classes. In slight to serious discrimination, the degree of seriousness shall be determined by the judge.

EYES

1. Total blindness: *Disqualification*
2. Blindness in one eye: Slight discrimination.
3. Cross-eyes: *Slight discrimination.*

WRY FACE

Slight to serious discrimination

CROPPED EARS

Slight discrimination

PARROT JAW

Slight to serious discrimination

SHOULDERS

Winged: Slight to serious discrimination

TAIL SETTING

Wry tail or other abnormal tail settings: Slight to serious discrimination.

LEGS AND FEET

1. Lameness—*apparently permanent and interfering with normal function: Disqualification.*
   —apparently temporary and not affecting normal function: Slight discrimination
2. Bucked knees: Slight to serious discrimination
3. Evidence of arthritis, crampy hind leg: Serious discrimination
4. Boggy hocks: *Slight to serious discrimination.*

ABSENCE OF HORNS

No discrimination.

LACK OF SIZE

Slight to serious discrimination.

UDDER

1. Blind quarter: Disqualification.
2. Abnormal milk (bloody, clotted, watery): *Possible disqualification*
3. Udder definitely broken away in attachment: Serious discrimination
4. A weak udder attachment: Slight to serious discrimination
5. *One or more light quarters, hard spots in udder, obstruction in teat (spider):* Slight to serious discrimination
6. Side leaks: Slight discrimination.

DRY COWS

Among cows of apparently equal merit: Give strong preference to cows in milk.

FREEMARTIN HEIFERS

Disqualification *unless proved pregnant*

OVERCONDITIONED

Slight to serious discrimination.

TEMPORARY OR MINOR INJURIES

Blemishes or injuries of a temporary character not affecting animal's usefulness: *Slight discrimination.*

EVIDENCE OF SHARP PRACTICE

1. Animals showing signs of having been operated upon or tampered with for the purpose of concealing faults in conformation or with intent to deceive relative to the animal's soundness: Disqualification
2. *Uncalved heifers showing evidence of having been milked:* Serious discrimination.

6 METHODS OF PRODUCTION TESTING

THE DAIRY HERD IMPROVEMENT ASSOCIATION (DHIA) PROGRAM IS open to all types of milk production operations. Each locality forms a cooperative organization which handles finances, hires a tester, buys necessary equipment, has a constitution and bylaws, keeps records, and develops a program of herd improvement. The local associations work closely with county and state extension personnel and with the National Cooperative Dairy Herd Improvement program. There are three general plans under DHIA.

1. *Standard DHIA*. The supervisor hired by the association calls on each member once each month and performs the following services:

(a) Weighs milk from each cow for two consecutive milkings.
(b) Determines fat percentage on composite samples for each cow.
(c) Calculates standard feed and production records or assembles data for central processing, which is done on a regional basis by means of electronic computers
(d) Identifies each cow by registration number for purebreds or herd number for grades Thus a lifetime record is established for individual cows
(e) Enters records in the dairyman's herd-record book The records include production to date, month- and year-to-date herd totals, total and average feed cost, and income over feed cost
(f) Makes suggestions for feeding according to stage of lactation, production, condition, and feed available
(g) Records dates of breeding and suggests drying-off dates based on expected calving dates
(h) Records sire, dam, sex, and birth dates of calves
(i) Sends records to State Extension Dairymen for use in sire proofs and other DHIA promotions.

2. The *Owner-Sampler Plan* provides the same data but the records are not used in the National Sire Proving program because the supervisor does not weigh and sample the milk

The DHIA technician leaves sample bottles and record sheets with each dairyman once each month The owner then weighs and samples two con-

secutive milkings and fills in the record sheets His records may include also the amounts and kinds of feed used

The next day samples are tested in a central laboratory, calculations and recommendations are assembled and sent to the herd owner, usually by mail

3 The *Weigh a Day a Month* plan is simpler than either of the others Forms and instructions are obtained from county extension personnel The dairyman weighs the milk of each cow on the morning and evening of the 15th day of each month These weights along with feed data are mailed to a central office where calculations are made Records include the total and average feed costs and income over feed cost for the herd for each month and for the year

Official tests within each state are directed by a superintendent of official testing Most of these officials are on the staff of the extension service con nected with the State Agricultural Colleges The superintendent appoints supervisors to conduct the tests Usually, the same men conduct DHIA tests Rules for official testing have been formulated by the American Dairy Science Association, but the superintendent may modify them to meet special conditions within his jurisdiction

In all cases where official records are made the supervisor watches each cow milked, weighs and tests each cow's milk for butterfat, and reports the results on appropriate blanks He is an employee of the state, responsible to the superintendent of official testing

The testing of whole herds rather than selected individuals appears largely to be replacing other methods of official testing When employed for several generations in the same herd, it provides an extremely valuable set of records Thus a reliable index as to the worth of a herd is established Dam and daughter comparisons, the effects of sires, and the value of various managemental factors can be evaluated

For herds which use regional electronic computing services, DHIA records can be official herd tests for purebred cattle This provision, known as *Dairy Herd Improvement Registry* (DHIR) is contingent upon approval by the breed association concerned Under this form of testing all cows in the herd must be included and the test period is for one year beginning at any time Tests are made once a month *for a 24 hour period Daily milk* weights and preliminary milkings are not required but surprise tests may be arranged at the discretion of the breed association

Herd Improvement Registry (HIR) testing is available to all purebred herds, and will be conducted essentially as described above These records are not computed along with DHIA records and may not include recommendations for feeding and management

Advanced Registry is open to registered animals which show a high order of dairy merit Individual cows may be tested at the discretion of the owner The exact requirements vary with the association but all major dairy breed associations sponsor some form of registration based on performance as shown in Table C-1

Table C-1 Various Plans of Advanced Registration

Breed	Date Organized	Title of Register
Holstein	1885	Advanced Register (AR)
Guernsey	1901	Advanced Register (AR)
Jersey	1902	Register of Merit (ROM)
Ayrshire	1902	Advanced Register (AR)
Brown Swiss	1911	Register of Production (ROP)

All forms of AR, RM, or ROP testing apply to selected animals It establishes their value perhaps better than anything else, since there is no question as to the accuracy of official records Preliminary dry milking is required at the beginning of each test period Individual butterfat samples and daily milk weights also are necessary

In addition to records for purposes of business, official tests may be published in the breed journals They also are used (1) in pedigrees, (2) in sire summaries, (3) for individual awards (4) for class records, (5) state records, (6) official news releases, (7) lifetime production credits, (8) sire evaluation, (9) tested dam ratings, and (10) various other purposes of publicity and recognition as sponsored by the breed associations

D

NUTRIENT REQUIREMENTS

OF DAIRY CATTLE AS REPORTED BY THE COMMITTEE ON ANIMAL NUTRITION NATIONAL ACADEMY OF SCIENCES NATIONAL RESEARCH COUNCIL (REPRINTED BY SPECIAL PERMISSION)

NOTE For information on the use of the feeding standard in Appendix D, and for related material on ration formulation see pages 136 40 For a more fundamental background see pages 18 29

Table D 1 Daily Nutrient Requirements of Dairy Cattle (Based on Air dry Feed Containing 90 Per Cent Dry Matter)

	Daily Gain		Daily Nutrients per Animal[1]								
Body wt (lb)	Small Breeds (lb)	Large Breeds (lb)	Feed (lb)	Protein (lb)	Digestible Protein (lb)	TDN (lb)	DE[2] (therm)	Ca (gm)	P (gm)	Carotene (mg)	Vitamin D (IU)
			Normal Growth of Dairy Heifers								
50	0 5	—	0 9	0 31	0 20	1 0	2 0	4	3	2[3]	150
100	1 0	0 8	2 0	0 62	0 40	2 0	4 0	7	6	4	300
150	1 3	1 4	4 0	0 78	0 50	3 0	6 1	12	10	6	450
200	1 4	1 6	6 0	0 94	0 60	4 0	8 1	13	10	8	600
400	1 2	1 8	11 0	1 25	0 80	6 5	13 1	13	12	16	[4]
600	0 8	1 4	15 0	1 33	0 85	8 5	17 1	13	12	24	—
800	1 1	1 2	19 0	1 40	0 90	10 0	20 2	13	12	32	—
1000	—	1 3	22 0	1 48	0 95	11 0	22 2	12	12	40	—
1200	—	1 2	24 0	1 56	1 00	12 0	24 2	12	12	48	—
			Maintenance of Mature Cows[5]								
800	—	—	12	0 95	0 50	6 0	11 7	6	6	32	[4]
1000	—	—	14	1 13	0 60	7 0	14 1	8	8	40	—
1200	—	—	16	1 32	0 70	8 0	16 6	10	10	48	—
1400	—	—	19	1 51	0 80	9 0	19 0	11	11	56	—
1600	—	—	21	1 64	0 87	10 0	21 2	12	12	64	—
			Reproduction (Add to Maintenance During last 2 to 3 Months)								
—	2 0	2 0	8 0	1 13	0 60	6 0	12 1	8	7	30	[4]
			Lactation (Add to Maintenance for Each Pound of Milk)								
—	—	3 0% fat	—	0 062	0 040	0 28	0 57	1	0 7	[6]	[6]
—	—	4 0% fat	—	0 070	0 045	0 32	0 65	1	0 7	—	—
—	—	5 0% fat	—	0 078	0 050	0 37	0 75	1	0 7	—	—
—	—	6 0% fat	—	0 086	0 055	0 42	0 85	1	0 7	—	—

(continued)

Table D-1. (Continued)

	Daily Gain		Daily Nutrients per Animal[1]								
Body wt	Small Breeds	Large Breeds	Feed	Protein	Digestible Protein	TDN	DE[2]	Ca	P	Carotene	Vitamin D
(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(therm)	(gm)	(gm)	(mg)	(IU)
Maintenance of Breeding Bulls											
1200	—	—	18	1.56	1.00	10.3	20.8	10	10	48	—
1600	—	—	22	1.87	1.20	12.9	26.1	12	12	64	—
2000	—	—	27	2.20	1.45	15.6	31.5	16	16	80	—
2400	—	—	31	2.50	1.60	18.2	36.8	19	19	96	—

[1]Thiamine, riboflavin, niacin, pyridoxine, pantothenic acid, folic acid, vitamin B12, and and vitamin K are synthesized by bacteria in the rumen, and it appears that adequate amounts of these vitamins are furnished by a combination of rumen synthesis and natural feedstuffs. Manganese, magnesium, iron, copper, and cobalt are essential, and the amounts needed are discussed on pages 65, 128, 135, 141.

[2]DE (digestible energy) was calculated on the assumption that one gram of TDN has 4.4 kcal of digestible energy (2000 kcal/lb), a value based largely on the extensive summary of published data made by B. H. Schneider. DE may be converted to metabolizable energy by multiplying by 82 per cent.

[3]Calves should receive colostrum the first few days after birth, as a source of vitamin A and other essential factors.

[4]While vitamin D is known to be required, the data are inadequate to warrant specific figures for older growing animals and for maintenance, reproduction, and lactation.

[5]When calculating the intakes for lactating heifers that are still growing, it is recommended that the figure for growth rather than maintenance be used.

[6]When adequate amounts of vitamins A and D are fed for normal reproduction, extra amounts will not stimulate milk production but will increase the vitamin content of the milk. Intakes of 200 mg of carotene per day will give optimum content of vitamin A in milk.

Table D-2. Nutrient Content of Rations for Dairy Cattle (Based on Air-dry Feed Containing 90 Per Cent Dry Matter)

	Average Age		Per Cent of Ration or Amount Per Pound of Feed								
Body wt	Small Breeds	Large Breeds	Total Daily Feed	Feed % of wt	Digestible Protein	TDN	DE[1]	Ca	P	Carotene	Vitamin D
(lb)	(months)	(months)	(lb)	(%)	(%)	(%)	(therms/lb)	(%)	(%)	(mg/lb)	(IU/lb)
Normal Growth of Dairy Heifers											
50	birth	—	0.9	1 6	22.0	110	2 22	0.98	0.73	—	170
100	2.3	0.6	2.0	2.0	20.0	100	2.02	0.77	0.66	2.0	150
150	3 7	2.0	4.0	2.7	12.5	75	1 52	0.66	0.44	1.5	110
200	4.8	3.1	6.0	3.0	10.0	67	1.35	0 48	0.40	1.3	100
400	10.0	6.7	11.0	2 8	7.3	59	1 19	0.26	0.30	1 5	—
600	17.2	10.8	15 0	2.7	5.7	57	1.15	0.19	0.22	1 6	—

(continued)

Table D 2 (Continued)

	Average Age		Per Cent of Rat on or Amount Per Pound of Feed								
Body wt	Small Breeds	La ge B eeds	Total Da ly Feed	Feed % of wt	D gest ble Prote n	TDN	DE[1]	Ca	P	Caro- tene	V ta m n D
(lb)	(months)	(months)	(lb)	(%)	(%)	(%)	(the ms/lb)	(%)	(%)	(mg/lb)	(IU/lb)
				Normal Growth of Da ry He fers (Continued)							
800	28 0	16 0	19 0	2 5	4 7	53	1 07	0 15	0 15	1 7	—
1000	—	22 0	22 0	2 2	4 3	50	1 01	0 13	0 13	1 8	—
1200	—	36 0	24 0	2 0	4 2	50	1 01	0 12	0 12	2 0	—
				Maintenance of Mature Cows							
800	—	—	12	1 8	3 6	50	1 01	0 12	0 12	2 3	—
1000	—	—	14	1 6	3 7	50	1 01	0 12	0 12	2 5	—
1200	—	—	16	1 5	3 9	50	1 01	0 12	0 12	2 7	—
1400	—	—	19	1 4	3 8	50	1 01	0 12	0 12	2 7	—
1600	—	—	21	1 3	3 8	50	1 01	0 12	0 12	2 8	—
				Lactat ng Cows							
—	—	—	—	—	6 5	60	1 21	0 30	0 25	1 2	—
				Ma ntenance of Breed ng Bulls							
1200	—	—	18	1 5	5 6	58	1 17	0 12	0 12	2 7	—
1600	—	—	22	1 4	5 5	58	1 17	0 13	0 13	2 9	—
2000	—	—	27	1 3	5 4	58	1 17	0 13	0 13	3 0	—
2400	—	—	31	1 3	5 2	58	1 17	0 14	0 14	3 1	—

[1] DE (d gestible energy) may be converted to metabolizable energy by multiply ng by 82 per cent

Table D 3 Average Compos tion and D gestible Nutr ents

Feedstuff	Total dry matte	P o e n	D g prote n	TDN[1]	DE[2]	Calc um	Phos phorus	Caro tene
	(%)	(%)	(%)	(%)	(therms/lb)	(%)	(%)	(mg/lb)
				Dry Roughages				
Alfalfa hay all analyses	90 5	15 3	10 9	50 7	1 02	1 47	0 24	8 2
Alfalfa hay 1/10 to 1/2 bloom	90 5	15 4	11 2	51 4	1 04	1 47	0 24	20 3
Alfalfa hay 3/4 to full bloom	90 5	14 1	10 2	50 3	1 02	1 22	0 22	8 5
Alfalfa hay past bloom	90 5	12 9	9 3	47 7	0 96	1 10	0 20	3 3
Alfalfa meal dehydrated	92 7	17 7	12 4	54 4	1 10	1 60	0 26	42 4
Alfalfa leaf meal dehydrated	92 7	21 1	16 0	57 2	1 16	1 69	0 25	62 9
Barley hay	90 8	7 3	4 0	51 9	1 05	0 26	0 23	—
Barley straw	90 0	3 7	0 7	42 2	0 85	0 33	0 10	—

(cont nued)

Table D-3. (Continued)

Feedstuff	Total dry matter (%)	Protein (%)	Dig. protein (%)	TDN[1] (%)	DE[2] (therms/lb)	Calcium (%)	Phos-phorus (%)	Caro-tene (mg/lb)
Dry Roughages								
Birdsfoot trefoil hay	91.2	14.2	9.8	55 0	1.11	1.60	0.20	19.7
Bromegrass hay, all analyses	88.8	10.4	5.3	49.3	1.00	0.42	0.19	—
Clover hay, alsike, all analyses	88.9	12.1	8.1	53.2	1.07	1.15	0.23	—
Clover hay, crimson	89.5	14.2	9.8	48.9	0.99	1.23	0.24	—
Clover hay, Ladino	89.5	18.5	14.2	59.5	1.20	1.53	0.29	—
Clover hay, red, all analyses	88.3	12.0	7.2	51.8	1.05	1.28	0.20	7.3
Clover and mixed grass hay, high in clover	89.6	9.6	5.5	51.8	1.05	0.88	0.21	6.1
Clover and timothy hay, 30 to 50% clover	88.1	8.6	4.7	51.0	1.03	0.69	0.16	—
Corn cobs, ground	90.4	2.3	0.0	45.7	0.92	0.11	0.04	—
Corn fodder, medium, in water	82 6	6.8	3.3	53.9	1.09	0.25	0.14	1.8
Corn stover, medium, in water	80.3	5.8	2.0	45.5	0.92	0.48	0.08	—
Cowpea hay, all analyses	90.4	18.6	12.3	51.4	1.04	1.37	0.30	—
Kafir fodder, very dry	90.0	8.7	4.5	53 6	1.08	0.35	0.18	2.0
Kafir stover, very dry	90.0	5.5	1.9	51.3	1.04	0.54	0.09	1.1
Lespedeza hay, annual, before bloom	89.1	14 3	7.2	49.2	0.99	1.03	0.20	20.4
Lespedeza hay, annual, in bloom	89.1	13.0	6 4	46.4	0.94	1.00	0.19	—
Lespedeza hay, annual, after bloom	89.1	11.5	3.6	39.6	0.80	0.90	0.15	—
Mixed hay, good, less than 30% legumes	89.2	8.8	4.8	48.8	0.99	0.90	0.19	6.4
Oat hay	88.1	8.2	4.9	47.3	0.96	0.21	0.19	—
Oat straw	89.8	4.1	0.7	44.8	0.90	0.24	0.09	—
Orchard grass hay, good	88.7	8.1	4.2	49.7	1.00	0.27	0.18	—
Pea hay, field	89.3	14.9	10.6	55.1	1.11	1.22	0.25	—
Peanut hay, mowed	91.4	10.6	6.9	58.4	1.18	—	—	8.0
Prairie hay, western, cut in mid-season	91.3	6.0	2.0	45.1	0.91	0.33	0.12	9.1
Prairie hay, western, mature	91.9	4.4	0.9	43.7	0.88	0.36	0.08	3.6
Quack grass hay	89.0	6.9	2.5	40.3	0.81	—	—	—
Reed canary grass hay	91.1	7.7	4.9	45.1	0.91	0.33	0.16	—
Rye hay	91.3	6.7	2.4	42.5	0.86	—	0.18	—
Rye straw	92.8	3.5	0	42.2	0.85	0.26	0.09	—
Sorghum fodder, sweet, dry	88.9	6.2	3.3	52.4	1.06	0.34	0.14	1.1

(continued)

Table D 3 (Continued)

Feedstuff	Total dry matter (%)	Protein (%)	Dig protein (%)	TDN[1] (%)	DE[2] (therms/lb)	Calcium (%)	Phosphorus (%)	Carotene (mg/lb)
Dry Roughages (Continued)								
Soybean hay, good, all analyses	88 1	14 6	9 8	48 6	0 98	1 10	0 22	13 6
Soybean hay, in bloom or before	88 0	16 7	12 0	52 4	1 06	1 29	0 34	—
Soybean hay, seed developing	88 0	14 6	9 8	48 2	0 97	1 24	0 25	13 6
Soybean hay, seed nearly ripe	88 0	15 2	10 8	54 9	1 11	0 96	0 31	3 0
Soybean straw	88 9	3 9	1 1	38.6	0 78	—	0 05	—
Sudan grass hay, all analyses	89 4	8 8	4 3	48 6	0 98	0 36	0 27	—
Timothy hay, all analyses	89 0	6 6	3 0	49 1	0 99	0 35	0 14	4 4
Timothy hay, before bloom	89 0	9 7	6 1	56 6	1 14	—	—	9 2
Timothy hay, full bloom	89 0	6 4	3 2	51 1	1 03	—	0 20	4 2
Timothy hay, late seed	89 0	5 3	1 9	41 9	0 85	0 14	0 15	2 5
Timothy and clover hay, 1/4 clover	88 8	7 9	4 0	49 8	1 01	0 58	0 15	—
Vetch and oat hay, over 1/2 vetch	87 6	11 9	8 4	50 7	1 02	0 76	0 27	—
Wheat hay	90 4	6 1	3 3	46 7	0 94	0 14	0 18	—
Wheat straw	92 6	3 9	0 3	40 6	0 82	0 15	0 07	—
Silages, Roots, and Tubers								
Alfalfa, not wilted, no preservative	24 7	4 1	2 6	13 5	0 27	0 35	0 08	15 1
Alfalfa, wilted	36 2	6 3	4 3	21 5	0 43	0 51	0 12	11 4
Alfalfa-molasses, not wilted	26 8	4 1	2 7	15 4	0 31	0 41	0 08	14 5
Beet top, sugar	31 6	3 8	2 5	14 9	0 30	0 31	0 07	5 1
Cabbage entire	9 4	2 2	1 9	8 1	0 16	0 06	0 03	—
Carrots, roots	11 9	1 2	0 9	10 3	0 21	0 05	0 04	—
Clover, Lad no, and timothy	29 9	5 4	3 9	21 4	0 43	0 31	0 07	15 6
Corn, canning factory waste	22 4	2 0	1 1	16 1	0 33	—	—	—
Corn, dent, well matured, all analyses	27 6	2 3	1 2	18 3	0.37	0 10	0 07	5 8
Corn, dent, well matured, well eared	28 5	2 3	1 3	19 8	0 40	0 09	0 07	—
Corn, dent, well matured, fair in ears	26 3	2.1	1 1	17 2	0.35	0 09	0 06	—
Corn, dent, immature before dough stage	20 3	1 8	0 9	12 9	0 26	0 11	0 07	—
Corn stover, mature ears removed	23 7	1 6	0 6	14 0	0 28	0 08	0 10	—

(continued)

Table D-3. (Continued)

Feedstuff	Total dry matter (%)	Protein (%)	Dig. protein (%)	TDN[1] (%)	DE[2] (therms/lb)	Calcium (%)	Phosphorus (%)	Carotene (mg/lb)
Silages, Roots, and Tubers (Continued)								
Corn and soybeans, well matured 30% or more soybeans	28.3	3.2	2.0	19.7	0.40	0.20	0.08	—
Grass silage, considerable legumes	25.6	3.6	2.0	15.5	0.31	—	—	17.1
Grass silage, some legumes	27.6	3.2	1.9	15.6	0.32	—	—	20.7
Grass silage, some legumes, molasses added	25.8	3.2	1.9	15.1	0.31	0.32	0.12	—
Grass silage wilted, molasses added	33.6	4.5	2.6	19.1	0.39	—	—	6.2
Mangels, roots	9.2	1.3	0.9	7.1	0.14	0.02	0.02	—
Oats, molasses added	32.0	2.7	1.4	16.9	0.34	0.10	0.09	17.7
Pea vine	24.5	3.2	1.9	14.0	0.30	0.32	0.06	21.0
Potatoes, tubers	21.2	2.2	1.3	17.4	0.35	0.01	0.05	—
Potato-alfalfa hay	35.9	5.3	3.3	21.1	0.43	—	—	—
Potato-mixed hay	33.7	3.8	2.2	21.6	0.44	—	—	—
Potato-corn meal	31.7	2.0	1.0	27.0	0.55	—	—	—
Rutabagas, roots	11.1	1.3	1.0	9.5	0.19	0.05	0.03	—
Sorghum, sweet	25.4	1.6	0.8	15.2	0.31	0.08	0.05	2.7
Soybean, not wilted	24.8	4.2	2.9	14.6	0.29	0.35	0.09	14.6
Sudan grass	25.7	2.2	1.5	14.4	0.29	0.11	0.04	—
Timothy, not wilted, no preservative	30.9	3.3	1.8	18.4	0.37	0.18	0.09	14.1
Timothy, not wilted, molasses added	30.0	3.1	1.6	17.1	0.35	0.16	0.08	—
Turnips	9.3	1.3	0.9	7.8	0.16	0.06	0.02	—
Concentrates								
Barley, excluding Pacific Coast	89.4	12.7	10.0	77.7	1.57	0.06	0.40	—
Barley, Pacific Coast	89.9	8.7	6 9	78 8	1.59	0.06	0.33	—
Beans, field or navy	90.0	22.9	20.2	78.7	1 59	0.15	0.57	—
Beet, pulp, dried	90.8	9.1	4.3	68.2	1 38	0.68	0.10	—
Beet pulp, molasses, dried	92.0	9.1	6.0	72.3	1.46	0.56	0.08	—
Beet pulp, wet	11.6	1.5	0.8	8.8	0 18	0.09	0.01	—
Blood meal	90.5	79.9	56.7	58.9	1.19	0.28	0.22	—
Blood flour	90.8	82.2	78.9	81.2	1.64	0.45	0.37	—
Bone meal, raw	93.2	26.2	18.1	18.1	0.37	22.14	10.35	—
Bone meal, steamed	95.2	12.1	—	—	—	28.98	13.59	—
Brewers dried grains	92.4	25.9	20.7	66 0	1.33	0.27	0.50	—
Buttermilk, dried	92.5	32.0	28.8	83 0	1.68	1.34	0.94	—
Citrus pulp, dried	90.1	6.6	5.2	78.2	1.58	1.96	0.12	—
Coconut oil meal, expeller	92.8	20.4	17.3	76.3	1.54	0.21	0.61	—

(continued)

Table D 3 (Continued)

Feedstuff	Total dry matter (%)	Protein (%)	Dig. protein (%)	TDN[1] (%)	DE[2] (therms/lb)	Calcium (%)	Phosphorus (%)	Carotene (mg/lb)
Concentrates (Continued)								
Coconut oil meal, solvent	91.7	21.3	18.1	68.3	1.33	0.17	0.61	—
Corn and cob meal	86.1	7.4	5.4	73.2	1.43	0.04	0.27	—
Corn, yellow dent, #2	85.0	8.7	6.7	80.1	1.62	0.02	0.27	1.3
Corn, flint	88.5	9.8	7.5	83.4	1.68	—	0.33	—
Corn distillers dried grains	92.3	27.1	19.8	82.7	1.67	0.09	0.37	1.4
Corn distillers dried grains with solubles	91.9	27.2	17.9	81.0	1.64	0.17	0.43	1.7
Corn distillers dried solubles	93.1	26.9	21.3	80.2	1.62	0.35	1.37	0.3
Corn gluten feed	90.4	25.3	21.8	75.4	1.52	0.46	0.77	3.8
Corn gluten meal	90.7	42.9	36.5	79.9	1.61	0.16	0.40	7.4
Cottonseed, whole, pressed	92.4	28.0	20.2	58.6	1.18	0.17	0.64	—
Cottonseed feed	90.8	39.2	30.6	65.4	1.32	0.15	0.64	—
Cottonseed oil meal, expeller	92.7	41.4	34.4	73.4	1.48	0.18	1.15	—
Cottonseed oil meal, solvent	91.4	41.6	34.5	66.1	1.34	0.15	1.10	—
Fish meal, menhaden	92.2	61.3	49.7	67.0	1.35	5.49	2.81	—
Flaxseed screenings	91.4	15.8	8.8	58.5	1.18	0.37	0.43	—
Flaxseed screenings oil feed	91.3	24.1	13.5	54.6	1.10	0.44	0.63	—
Hominy feed, white	89.8	11.1	7.9	82.9	1.67	0.02	0.58	—
Hominy feed, yellow	90.7	11.1	7.9	83.7	1.69	0.05	0.52	3.1
Linseed feed	90.5	33.8	28.4	74.2	1.50	0.43	0.65	—
Linseed oil meal, expeller	90.9	35.3	30.7	76.3	1.54	0.44	0.87	—
Linseed oil meal, solvent	90.9	35.1	29.5	71.0	1.43	0.40	0.83	—
Meat scrap	93.5	53.4	43.8	65.4	1.32	7.9	4.03	—
Meat scrap, 50% protein	94.0	50.6	41.5	62.2	1.26	10.57	5.07	—
Milk, cow's	12.8	3.5	3.3	16.3	0.33	0.12	0.10	—
Milk, ewe's	19.2	6.5	6.2	26.2	0.53	0.21	0.12	—
Molasses, beet	76.0	6.7	3.5	59.6	1.20	0.16	0.03	—
Molasses, cane	74.5	3.2	2.0	54.9	1.11	0.89	0.08	—
Molasses, cane, dried	96.1	10.3	—	62.6	1.26	—	—	—
Oats, excluding Pacific Coast	90.2	12.0	9.4	70.1	1.42	0.09	0.33	—
Oats, Pacific Coast	91.2	9.0	7.0	72.2	1.46	—	—	—
Oats, rolled (oatmeal)	90.8	16.1	14.5	91.4	1.85	0.07	0.46	—
Oats groats, (hulled)	90.4	16.2	14.6	91.9	1.86	0.08	0.46	—
Orange pulp, dried	89.3	7.0	5.5	78.8	1.59	0.63	0.10	—
Oyster shell, ground	99.6	1.0	—	—	—	38.05	0.07	—
Peanut oil meal, expeller	92.0	45.8	41.7	80.2	1.62	0.17	0.57	—
Peanut oil meal, solvent	91.5	47.4	43.1	74.3	1.50	0.20	0.65	—
Potato meal, dried	90.3	5.9	2.1	65.1	1.32	—	—	—
Rape seed	90.5	20.4	17.3	117.1	2.37	—	—	—

(continued)

Table D-3. (Continued)

Feedstuff	Total dry matter (%)	Protein (%)	Dig. protein (%)	TDN[1] (%)	DE[2] (therms/lb)	Calcium (%)	Phosphorus (%)	Carotene (mg/lb)
Concentrates (Continued)								
Rice bran	90.6	13.5	9.2	71.0	1.43	0.06	1.82	—
Rice polishings	89.9	11.8	9.0	83.0	1.68	0.04	1.42	—
Rye grain	89.5	12.6	10.0	76.5	1.55	0.10	0.33	—
Rye distillers dried grains	93.0	22.4	13.4	60.2	1.22	0.13	0.41	—
Rye middlings	89.8	17.1	13.0	71.4	1.44	0.06	0.63	—
Safflower oil meal, expeller	90.6	19.7	15.8	48.4	0.98	0.23	0.71	—
Safflower oil meal, with hulls	93.2	23.7	19.0	51.5	1.04	—	—	—
Safflower oil meal, without hulls	91.1	38.4	33.8	64.4	1.30	0.31	0.58	—
Safflower seed	93.1	16.3	13.0	82.4	1.66	—	—	—
Skim milk, dried	93.9	33.5	30.2	80.3	1.62	1.26	1.03	—
Sorghum, Kafir	89.8	11.0	8.9	81.6	1.65	0.03	0.31	—
Sorghum, milo	89.0	10.9	8.5	79.4	1.60	0.03	0.28	—
Sorghum, milo, head chops	89.6	9.2	7.0	74.3	1.50	0.14	0.26	—
Soybeans	90 0	37.9	33.7	87.6	1.77	0.25	0.59	—
Soybean oil meal, expeller	89.7	43.8	36.8	77.0	1.56	0.27	0.63	—
Soybean oil meal, solvent	89.3	45.8	42.1	77.2	1.56	0.32	0.67	—
Sweet potato meal	90.2	4.9	0.7	72.7	1.47	0.15	0.14	32.2
Tankage, digester	92.1	59.8	50.8	66.1	1.34	5.94	3.17	—
Tankage, digester, with bone	94.1	49.6	42.2	64.7	1.31	10.97	5.14	—
Wheat, hard, winter	89.4	13.5	11.3	79.6	1.61	0.05	0.42	—
Wheat, hard, spring	90.1	15.8	13.3	80.7	1.63	0.04	0.40	—
Wheat, soft, winter	89.2	10.2	8.6	80.1	1.62	—	0.29	—
Wheat, soft, Pacific Coast	89.1	9.9	8.3	79.9	1.61	—	—	—
Wheat bran	89.1	16.0	13.0	65.9	1.33	0.14	1.17	1.2
Wheat flour middlings	89.8	18.4	16.2	78.2	1.58	0.11	0.76	—
Wheat germ oil meal	89.7	27.3	22.9	84.1	1.70	0.07	1.06	3.0
Wheat screenings, good grade	90.4	13.9	10.0	68.7	1.39	0.44	0.39	—
Wheat standard middlings	89.7	17.2	14.3	76.9	1.55	0.15	0.91	1.4
Whey, dried	93.5	13.1	11.8	78.4	1.58	0.87	0.79	—
Yeast, brewers dried	93.4	44.6	38.4	72.4	1.46	0.13	1.43	—
Yeast, torula, dried	93.3	48.3	41.5	69.9	1.41	0.57	1.68	—

[1]In calculating the values for total digestible nutrients, no digestion coefficients for a few feedstuffs were available, or the data were inadequate. In those instances the digestion coefficients for comparable feedstuffs were used.

[2]DE (digestible energy) may be converted to metabolizable energy by multiplying by 82 per cent.

The Committee on Animal Nutrition is indebted to Professor F. B. Morrison for the use of data from the 22nd Edition of *Feeds and Feeding* on the composition of roughages, silages, and cereals presented in this table. The data on the composition of by-product feeds

(continued)

Table D 3 (Continued)

were suppl ed by the Committee on Feed Composit on of the Nat onal Research Council (NRC Pub No 449, 1956) The digest on coeffic ents used in calculating the digestible protein and TDN were also taken with Professor Morrison s permission from the 22nd Edi tion of *Feeds and Feeding* These are based in part on the extensive compilation of d ges t on coefficients in *Feeds of the World* (W Va Agr Expt Sta., 1947), which was prepared by Dr B H Schneider at the request of the Committee on An mal Nutrition

Table D 4 Composition of Calcium and Phosphorus Supplements

Mineral Supplement	Calcium		Phosphorus		Fluorine
	(%)	(gm/lb)	(%)	(gm/lb)	(%)
Bone meal, raw, feeding	22 7	103	10 1	46	0 030
Bone meal, steamed	30 0	136	13 9	63	0 037
Defluorinated rock phosphate[1]	29 0	132	13 0	59	0.15 or less
Dicalcium phosphate	26 5	120	20 5	93	0 05
Limestone (high calcium)	38 3	174	nil	nil	—
Oyster shell flour	36 9	167	nil	nil	—

[1]High quality defluorinated rock phosphate should contain this amount of calcium and phosphorus and be no higher in fluorine than shown

Table D 5 Estimated Carotene Content of Feeds in Relation to Appearance and Methods of Conservation[1]

Feedstuff	Carotene (mg/lb)
Fresh green legumes and grasses, immature	15 to 40
Dehydrated alfalfa meal, fresh, dehydrated without field curing, very bright green color[2]	110 to 135
Dehydrated alfalfa meal after considerable time in storage, bright green color	50 to 70
Alfalfa leaf meal, bright green color	60 to 80
Legume hays, including alfalfa, very quickly cured with minimum sun exposure, bright green color, leafy	35 to 40
Legume hays, including alfalfa, good green color, leafy	18 to 27
Legume hays, including alfalfa, partly bleached, moderate amount of green color	9 to 14
Legume hays including alfalfa, badly bleached or discolored, traces of green color	4 to 8
Non legume hays, including timothy, cereal, and prairie hays, well cured, good green color	9 to 14
Non-legume hays, average quality, bleached, some green color	4 to 8
Legume silage	20 to 30

(continued)

Table D-5 (Continued)

Feedstuff	Carotene (mg/lb)
Green silage	5 to 20
Corn and sorghum silages, medium to good green color	2 to 10
Grains, mill feeds, protein concentrates, and byproduct concentrates, except yellow corn and its by-products	.01 to 0.2

[1]This table was prepared by the late H. R. Guilbert, Davis, California.
[2]Green color is not uniformly indicative of high carotene content.

Table D-6 Examples of Adequate Rations

	Total feed (lb)	Digestible protein (lb)	TDN (lb)	DE[1] (therms/lb)	Calcium (gm)	Phosphorus (gm)	Carotene (mg)
100 pound calf							
Nutrient requirements	—	0.40	2 0	4 0	7	6	4
Ration in pounds							
Whole milk, 12.0	—	0.40	1.94	3.9	6.5	3.4	—
400-pound heifer							
Nutrient requirements	11	0.80	6.5	13.1	13	12	16
Ration in pounds							
(1) Mixed clover-timothy hay 8.0, yellow corn 1.0, oats 1.0, linseed meal 1 0	11	0.85	6.4	12.9	29	16	72
(2) Legume hay 10.0, yellow corn 2.0 (oats or barley)	12	1.73	6.6	13.3	67	13	117
00-pound heifer							
Nutrient requirements	15	0.85	8.5	17.2	13	12	24
Ration in pounds							
(1) Mixed legume-grass hay 10.0, oats 5.0 (corn or barley)	15	0.90	8.5	17.2	30	12-15	90
(2) Alfalfa hay 15.0	15	1.58	7.6	15.4	100	16	170
(3) Timothy hay 10.0, barley 5.0, limestone 0.05	15	.79	8.8	17.8	20	20	53
(4) Alfalfa hay 10.0, corn silage 15.0	25	1.23	7.8	15.8	73.5	15	210

(continued)

Table D-6. (Continued)

	Total feed (lb)	Digestible protein (lb)	TDN (lb)	DE[1] (therms/lb)	Calcium (gm)	Phosphorus (gm)	Carotene (mg)
Mature lactating cows							
1400-pound cow giving 50 lb. 4% milk							
Nutrient requirements	—	3.05	25.0	51.5	61	46	56
Ration in pounds:							
(1) Alfalfa 35, barley 12	—	4.87	26.9	54.3	279	94	400
(2) Timothy hay 14, corn silage 42, corn and cob meal 12, soybean meal 5, limestone 0.2	—	3.36	27.0	54.5	65	59	340
(3) Alfalfa hay 20.0, corn silage 50.0	—	3.30	26.8	54.1	156.8	46.2	558
1000-pound cow giving 35 lb. 5% milk							
Nutrient requirements	—	2.35	20.0	40.5	43	32	40
Ration in pounds:							
(1) Alfalfa hay 5, citrus pulp 12, hominy feed 10, cottonseed meal 2	—	2.45	21.3	43.0	161	46	57
(2) Clover-timothy mixed hay 10, corn silage 30, barley 4, oats 5, wheat bran 5	—	2.37	20.4	41.2	51	49	242
(3) Alfalfa brome hay 25.0 (at least 50% alfalfa), corn 11.0	—	2.69	21.2	42.8	95.9	43	—
(4) Alfalfa 15.0, corn silage 30.0, corn 10.0	—	2.48	21.0	42.4	100.8	42.2	421
(5) Clover-timothy 25.0 (30 to 50% clover), corn 10.0, soybean oil meal 1.0	—	2.24	21.5	43.4	79.6	37.6	—

[1] DE (digestible energy) may be converted to metabolizable energy by multiplying by 82 per cent.

Table D-7. Suggested Concentrate Mixtures for Dairy Animals

Roughage	Total Protein in Grain Mixture (%)	Ingredients[1] Corn (lb)	Oats (lb)	Wheat Bran (lb)	Soybean Oil Meal (lb)
Legume hay or legume silage (alfalfa, clover, soybean, etc.)	12–14	400	300	300	—
Legume hay and corn or grass silage or mixed hay and silage	14–16	300	300	300	100
Mixed hay and silage	16	200	300	300	200
Grass hay and corn silage[2]	16–18	100	300	300	300

[1]It is recommended that 1% salt be added. In phosphorus-deficient areas, 1% of bonemeal or other fluorine-low phosphorus supplement should be added.

[2]Add 1% calcium carbonate or ground limestone.

E

CALVING AND DRYING OFF

DATES BASED ON AVERAGE GESTATION PERIODS OF 282 DAYS

Table E 1

Bred	Dry off	Due	Bred	Dry off	Due	Bred	Dry off	Due
Jan.	Aug.	Oct	Feb.	Sept	Nov	Mar	Oct	Dec.
1	10	10	1	10	10	1	8	8
2	11	11	2	11	11	2	9	9
3	12	12	3	12	12	3	10	10
4	13	13	4	13	13	4	11	11
5	14	14	5	14	14	5	12	12
6	15	15	6	15	15	6	13	13
7	16	16	7	16	16	7	14	14
8	17	17	8	17	17	8	15	15
9	18	18	9	18	18	9	16	16
10	19	19	10	19	19	10	17	17
11	20	20	11	20	20	11	18	18
12	21	21	12	21	21	12	19	19
13	22	22	13	22	22	13	20	20
14	23	23	14	23	23	14	21	21
15	24	24	15	24	24	15	22	22
16	25	25	16	25	25	16	23	23
17	26	26	17	26	26	17	24	24
18	27	27	18	27	27	18	25	25
19	28	28	19	28	28	19	26	26
20	29	29	20	29	29	20	27	27
21	30	30	21	30	30	21	28	28
22	31	31		Oct	Dec	22	29	29
	Sept	Nov	22	1	1	23	30	30
23	1	1	23	2	2	24	31	31
24	2	2	24	3	3		Nov	Jan
25	3	3	25	4	4	25	1	1
26	4	4	26	5	5	26	2	2
27	5	5	27	6	6	27	3	3
28	6	6	28	7	7	28	4	4

(continued)

Table E-1. (Continued)

Bred	Dry off	Due	Bred	Dry off	Due	Bred	Dry off	Due
Jan.	Aug.	Oct.	Feb.	Sept.	Nov.	Mar.	Oct.	Dec.
29	7	7	29	8	8	29	5	5
30	8	8				30	6	6
31	9	9				31	7	7

Table E-2.

Bred	Dry off	Due	Bred	Dry off	Due	Bred	Dry off	Due
Apr.	Nov.	Jan.	May	Dec.	Feb.	June	Jan.	Mar.
1	8	8	1	8	7	1	8	10
2	9	9	2	9	8	2	9	11
3	10	10	3	10	9	3	10	12
4	11	11	4	11	10	4	11	13
5	12	12	5	12	11	5	12	14
6	13	13	6	13	12	6	13	15
7	14	14	7	14	13	7	14	16
8	15	15	8	15	14	8	15	17
9	16	16	9	16	15	9	16	18
10	17	17	10	17	16	10	17	19
11	18	18	11	18	17	11	18	20
12	19	19	12	19	18	12	19	21
13	20	20	13	20	19	13	20	22
14	21	21	14	21	20	14	21	23
15	22	22	15	22	21	15	22	24
16	23	23	16	23	22	16	23	25
17	24	24	17	24	23	17	24	26
18	25	25	18	25	24	18	25	27
19	26	26	19	26	25	19	26	28
20	27	27	20	27	26	20	27	29
21	28	28	21	28	27	21	28	30
22	29	29	22	29	28	22	29	31
23	30	30	23	30	Mar. 1	23	30	Apr. 1
24	Dec. 1	31	24	31	2	24	31	2
25	2	Feb. 1	25	Jan. 1	3	25	Feb. 1	3
26	3	2	26	2	4	26	2	4
27	4	3	27	3	5	27	3	5
28	5	4	28	4	6	28	4	6
29	6	5	29	5	7	29	5	7
30	7	6	30	6	8	30	6	8
			31	7	9			

Table E 3

Bred	Dry off	Due	Bred	Dry off	Due	Bred	Dry off	Due
July	Feb	Apr	Aug	Mar	May	Sept	Apr	June
1	7	9	1	10	10	1	10	10
2	8	10	2	11	11	2	11	11
3	9	11	3	12	12	3	12	12
4	10	12	4	13	13	4	13	13
5	11	13	5	14	14	5	14	14
6	12	14	6	15	15	6	15	15
7	13	15	7	16	16	7	16	16
8	14	16	8	17	17	8	17	17
9	15	17	9	18	18	9	18	18
10	16	18	10	19	19	10	19	19
11	17	19	11	20	20	11	20	20
12	18	20	12	21	21	12	21	21
13	19	21	13	22	22	13	22	22
14	20	22	14	23	23	14	23	23
15	21	23	15	24	24	15	24	24
16	22	24	16	25	25	16	25	25
17	23	25	17	26	26	17	26	26
18	24	26	18	27	27	18	27	27
19	25	27	19	28	28	19	28	28
20	26	28	20	29	29	20	29	29
21	27	29	21	30	30	21	30	30
22	28	30	22	31	31		May	July
	Mar	May		Apr	June	22	1	1
23	1	1	23	1	1	23	2	2
24	2	2	24	2	2	24	3	3
25	3	3	25	3	3	25	4	4
26	4	4	26	4	4	26	5	5
27	5	5	27	5	5	27	6	6
28	6	6	28	6	6	28	7	7
29	7	7	29	7	7	29	8	8
30	8	8	30	8	8	30	9	9
31	9	9	31	9	9			

Table E 4

Bred	Dry off	Due	Bred	Dry off	Due	Bred	Dry off	Due
Oct	May	July	Nov	June	Aug	Dec.	July	Sept
1	10	10	1	10	10	1	10	9
2	11	11	2	11	11	2	11	10
3	12	12	3	12	12	3	12	11

(continued)

Table E-4. (Continued)

Bred	Dry off	Due	Bred	Dry off	Due	Bred	Dry off	Due
Oct.	May	July	Nov.	June	Aug.	Dec.	July	Sept.
4	13	13	4	13	13	4	13	12
5	14	14	5	14	14	5	14	13
6	15	15	6	15	15	6	15	14
7	16	16	7	16	16	7	16	15
8	17	17	8	17	17	8	17	16
9	18	18	9	18	18	9	18	17
10	19	19	10	19	19	10	19	18
11	20	20	11	20	20	11	20	19
12	21	21	12	21	21	12	21	20
13	22	22	13	22	22	13	22	21
14	23	23	14	23	23	14	23	22
15	24	24	15	24	24	15	24	23
16	25	25	16	25	25	16	25	24
17	26	26	17	26	26	17	26	25
18	27	27	18	27	27	18	27	26
19	28	28	19	28	28	19	28	27
20	29	29	20	29	29	20	29	28
21	30	30	21	30	30	21	30	29
22	31	31		July		22	31	30
	June	Aug.	22	1	31		Aug.	Oct.
					Sept.			
23	1	1	23	2	1	23	1	1
24	2	2	24	3	2	24	2	2
25	3	3	25	4	3	25	3	3
26	4	4	26	5	4	26	4	4
27	5	5	27	6	5	27	5	5
28	6	6	28	7	6	28	6	6
29	7	7	29	8	7	29	7	7
30	8	8	30	9	8	30	8	8
31	9	9				31	9	9

Table E-5. Gestation Variation between Dairy Breeds*

Breed	Average Gestation Length
Ayrshire	278.7 days
Brown Swiss	290.8 days
Guernsey	284.0 days
Holstein	278.9 days
Jersey	279.3 days

*Breeding Committee, American Dairy Science Association.

F AGE CONVERSION FACTORS

FOR 305 DAY PRODUCTION RECORDS

NOTE For additional information, see page 223

Table F-1. Ayrshire

Age Yr	Age Mo	Factor	Age Yr.	Age Mo	Factor	Age Yr.	Age Mo.	Factor
1	9	1.36	5	3	1.02	10	6	1.03
1	10	1.34	5	4	1.02	10	7	1.03
1	11	1.32	5	5	1.02	10	8	1.03
2	0	1.30	5	6	1.02	10	9	1.03
2	1	1.29	5	7	1.01	10	10	1.03
2	2	1.28	5	8	1.01	10	11	1.03
2	3	1.27	5	9	1.01	11	0	1.04
2	4	1.26	5	10	1.01	11	1	1.04
2	5	1.25	5	11	1.01	11	2	1.04
2	6	1.24	6	0		11	3	1.04
2	7	1.23	to			11	4	1.04
2	8	1.22	7	11	1.00	11	5	1.04
2	9	1.21	8	0	1.00	11	6	1.05
2	10	1.20	8	1	1.01	11	7	1.05
2	11	1.19	8	2	1.01	11	8	1.05
3	0	1.18	8	3	1.01	11	9	1.05
3	1	1.17	8	4	1.01	11	10	1.05
3	2	1.16	8	5	1.01	11	11	1.05
3	3	1.15	8	6	1.01	12	0	1.06
3	4	1.14	8	7	1.01	12	1	1.06
3	5	1.14	8	8	1.01	12	2	1.06
3	6	1.13	8	9	1.01	12	3	1.06
3	7	1.13	8	10	1.01	12	4	1.06
3	8	1.12	8	11	1.01	12	5	1.06
3	9	1.12	9	0	1.02	12	6	1.07
3	10	1.11	9	1	1.02	12	7	1.07

(continued)

Table F-1. (Continued)

Age Yr.	Age Mo.	Factor	Age Yr.	Age Mo.	Factor	Age Yr.	Age Mo.	Factor
3	11	1.11	9	2	1.02	12	8	1.07
4	0	1.10	9	3	1.02	12	9	1.07
4	1	1.10	9	4	1.02	12	10	1.07
4	2	1.09	9	5	1.02	12	11	1.07
4	3	1.08	9	6	1.02	13	0	1.07
4	4	1.08	9	7	1.02	13	1	1.07
4	5	1.07	9	8	1.02	13	2	1.07
4	6	1.06	9	9	1.02	13	3	1.08
4	7	1.06	9	10	1.02	13	4	1.08
4	8	1.05	9	11	1.02	13	5	1.08
4	9	1.05	10	0	1.03	13	6	1.08
4	10	1.04	10	1	1.03	13	7	1.08
4	11	1.04	10	2	1.03	13	8	1.08
5	0	1.03	10	3	1.03	13	9	1.08
5	1	1.03	10	4	1.03	13	10	1.08
5	2	1.02	10	5	1.03	13	11	1.08
						14	0	

*Kendrick, op. cit.

Table F-2. Brown Swiss

Age Yr.	Age Mo.	Factor	Age Yr.	Age Mo.	Factor	Age Yr.	Age Mo.	Factor
1	9	1.48	5	3	1.03	10	6	1.03
1	10	1.47	5	4	1.03	10	7	1.03
1	11	1.46	5	5	1.02	10	8	1.03
2	0	1.45	5	6	1.02	10	9	1.03
2	1	1.44	5	7	1.02	10	10	1.03
2	2	1.43	5	8	1.01	10	11	1.03
2	3	1.41	5	9	1.01	11	0	1.04
2	4	1.39	5	10	1.01	11	1	1.04
2	5	1.37	5	11	1.01	11	2	1.04
2	6	1.35	6	0		11	3	1.04
2	7	1.33		to		11	4	1.04
2	8	1.31	7	11	1.00	11	5	1.04
2	9	1.29	8	0	1.00	11	6	1.05
2	10	1.27	8	1	1.01	11	7	1.05

(continued)

Table F-2 (Continued)

Age Yr	Age Mo	Factor	Age Yr.	Age Mo.	Factor	Age Yr.	Age Mo	Factor
2	11	1.25	8	2	1.01	11	8	1.05
3	0	1.23	8	3	1.01	11	9	1.05
3	1	1.21	8	4	1.01	11	10	1.05
3	2	1.20	8	5	1.01	11	11	1.05
3	3	1.19	8	6	1.01	12	0	1.06
3	4	1.18	8	7	1.01	12	1	1.06
3	5	1.17	8	8	1.01	12	2	1.06
3	6	1.16	8	9	1.01	12	3	1.06
3	7	1.15	8	10	1.01	12	4	1.06
3	8	1.14	8	11	1.01	12	5	1.06
3	9	1.13	9	0	1.01	12	6	1.07
3	10	1.12	9	1	1.01	12	7	1.07
3	11	1.11	9	2	1.01	12	8	1.07
4	0	1.10	9	3	1.01	12	9	1.07
4	1	1.09	9	4	1.01	12	10	1.07
4	2	1.09	9	5	1.01	12	11	1.07
4	3	1.08	9	6	1.02	13	0	1.08
4	4	1.08	9	7	1.02	13	1	1.08
4	5	1.07	9	8	1.02	13	2	1.08
4	6	1.07	9	9	1.02	13	3	1.08
4	7	1.06	9	10	1.02	13	4	1.08
4	8	1.06	9	11	1.02	13	5	1.08
4	9	1.05	10	0	1.02	13	6	1.09
4	10	1.05	10	1	1.02	13	7	1.09
4	11	1.04	10	2	1.02	13	8	1.09
5	0	1.04	10	3	1.02	13	9	1.09
5	1	1.04	10	4	1.02	13	10	1.09
5	2	1.03	10	5	1.02	13	11	1.09
						14	0	1.10

Table F-3 Guernsey

Age Yr	Age Mo.	Factor	Age Yr.	Age Mo.	Factor	Age Yr.	Age Mo.	Factor
1	9	1.31	5	3	1.01	10	6	1.05
1	10	1.28	5	4	1.01	10	7	1.05
1	11	1.26	5	5	1.01	10	8	1.05

(continued)

Table F-3. (Continued)

Age Yr.	Age Mo.	Factor	Age Yr.	Age Mo.	Factor	Age Yr.	Age Mo.	Factor
2	0	1.24	5	6	1.01	10	9	1.05
2	1	1.23	5	7 to		10	10	1.05
2	2	1.22	7	5	1.00	10	11	1.05
2	3	1.21	7	6	1.01	11	0	1.06
2	4	1.20	7	7	1.01	11	1	1.06
2	5	1.19	7	8	1.01	11	2	1.06
2	6	1.18	7	9	1.01	11	3	1.06
2	7	1.17	7	10	1.01	11	4	1.06
2	8	1.16	7	11	1.01	11	5	1.06
2	9	1.15	8	0	1.01	11	6	1.07
2	10	1.14	8	1	1.02	11	7	1.07
2	11	1.13	8	2	1.02	11	8	1.07
3	0	1.12	8	3	1.02	11	9	1.07
3	1	1.11	8	4	1.02	11	10	1.07
3	2	1.10	8	5	1.02	11	11	1.07
3	3	1.09	8	6	1.02	12	0	1.08
3	4	1.09	8	7	1.02	12	1	1.08
3	5	1.09	8	8	1.02	12	2	1.08
3	6	1.08	8	9	1.02	12	3	1.08
3	7	1.08	8	10	1.02	12	4	1.08
3	8	1.08	8	11	1.02	12	5	1.08
3	9	1.07	9	0	1.02	12	6	1.09
3	10	1.07	9	1	1.03	12	7	1.09
3	11	1.07	9	2	1.03	12	8	1.09
4	0	1.06	9	3	1.03	12	9	1.09
4	1	1.06	9	4	1.03	12	10	1.09
4	2	1.06	9	5	1.03	12	11	1.09
4	3	1.05	9	6	1.03	13	0	1.10
4	4	1.05	9	7	1.03	13	1	1.10
4	5	1.05	9	8	1.03	13	2	1.10
4	6	1.04	9	9	1.03	13	3	1.10
4	7	1.04	9	10	1.03	13	4	1.10
4	8	1.04	9	11	1.03	13	5	1.10
4	9	1.03	10	0	1.04	13	6	1.11
4	10	1.03	10	1	1.04	13	7	1.11
4	11	1.03	10	2	1.04	13	8	1.11
5	0	1.02	10	3	1.04	13	9	1.11
5	1	1.02	10	4	1.04	13	10	1.11
5	2	1.02	10	5	1.04	13	11	1.11
						14	0	1.12

Table F-4. Holstein and Red Dane

Age			Age			Age		
Yr.	Mo.	Factor	Yr.	Mo.	Factor	Yr.	Mo.	Factor
1	9	1.37	5	0	1.02	10	6	1.05
1	10	1.35	5	1	1.02	10	7	1.05
1	11	1.33	5	2	1.02	10	8	1.05
2	0	1.31	5	3	1.02	10	9	1.06
2	1	1.30	5	4	1.02	10	10	1.06
2	2	1.29	5	5	1.02	10	11	1.06
2	3	1.28	5	6	1.02	11	0	1.06
2	4	1.26	5	7	1.01	11	1	1.06
2	5	1.25	5	8	1.01	11	2	1.06
2	6	1.24	5	9	1.01	11	3	1.07
2	7	1.23	5	10	1.01	11	4	1.07
2	8	1.22	5	11	1.01	11	5	1.07
2	9	1.21	6	0		11	6	1.07
2	10	1.20	to			11	7	1.08
2	11	1.19	8	5	1.00	11	8	1.08
3	0	1.18	8	6	1.01	11	9	1.08
3	1	1.17	8	7	1.01	11	10	1.08
3	2	1.16	8	8	1.01	11	11	1.09
3	3	1.15	8	9	1.02	12	0	1.09
3	4	1.14	8	10	1.02	12	1	1.09
3	5	1.13	8	11	1.02	12	2	1.09
3	6	1.12	9	0	1.02	12	3	1.10
3	7	1.12	9	1	1.02	12	4	1.10
3	8	1.11	9	2	1.02	12	5	1.10
3	9	1.10	9	3	1.03	12	6	1.10
3	10	1.10	9	4	1.03	12	7	1.11
3	11	1.09	9	5	1.03	12	8	1.11
4	0	1.08	9	6	1.03	12	9	1.11
4	1	1.07	9	7	1.03	12	10	1.11
4	2	1.06	9	8	1.03	12	11	1.12
4	3	1.05	9	9	1.04	13	0	1.12
4	4	1.05	9	10	1.04	13	1	1.12
4	5	1.04	9	11	1.04	13	2	1.12
4	6	1.04	10	0	1.04	13	3	1.13
4	7	1.03	10	1	1.04	13	4	1.13
4	8	1.03	10	2	1.04	13	5	1.13
4	9	1.03	10	3	1.05	13	6	1.13
4	10	1.03	10	4	1.05	13	7	1.14

(continued)

Table F-4. (Continued)

Age Yr.	Age Mo.	Factor	Age Yr.	Age Mo.	Factor	Age Yr.	Age Mo.	Factor
4	11	1.03	10	5	1.05	13	8	1.14
						13	9	1.14
						13	10	1.14
						13	11	1.14
						14	0	1.15

Table F-5. Jersey

Age Yr	Age Mo.	Factor	Age Yr.	Age Mo.	Factor	Age Yr.	Age Mo.	Factor
1	9	1.32	5	3	1.01	10	6	1.05
1	10	1.30	5	4	1.01	10	7	1.05
1	11	1.28	5	5	1.01	10	8	1.05
2	0	1.27	5	6	1.01	10	9	1.05
2	1	1.26	5	7 to		10	10	1.05
2	2	1.25	7	5	1.00	10	11	1.05
2	3	1.24	7	6	1.01	11	0	1.06
2	4	1.23	7	7	1.01	11	1	1.06
2	5	1.22	7	8	1.01	11	2	1.06
2	6	1.21	7	9	1.01	11	3	1.06
2	7	1.20	7	10	1.01	11	4	1.06
2	8	1.19	7	11	1.01	11	5	1.06
2	9	1.18	8	0	1.01	11	6	1.07
2	10	1.17	8	1	1.02	11	7	1.07
2	11	1.16	8	2	1.02	11	8	1.07
3	0	1.15	8	3	1.02	11	9	1.07
3	1	1.14	8	4	1.02	11	10	1.07
3	2	1.13	8	5	1.02	11	11	1.07
3	3	1.12	8	6	1.02	12	0	1.08
3	4	1.11	8	7	1.02	12	1	1.08
3	5	1.10	8	8	1.02	12	2	1.08
3	6	1.09	8	9	1.02	12	3	1.08
3	7	1.09	8	10	1.02	12	4	1.08
3	8	1.08	8	11	1.02	12	5	1.08
3	9	1.08	9	0	1.02	12	6	1.09
3	10	1.07	9	1	1.03	12	7	1.09

(continued)

Table F-5. (Continued)

Age Yr.	Age Mo.	Factor	Age Yr.	Age Mo.	Factor	Age Yr.	Age Mo.	Factor
3	11	1.07	9	2	1.03	12	8	1.09
4	0	1.06	9	3	1.03	12	9	1.09
4	1	1.06	9	4	1.03	12	10	1.09
4	2	1.05	9	5	1.03	12	11	1.09
4	3	1.05	9	6	1.03	13	0	1.10
4	4	1.04	9	7	1.03	13	1	1.10
4	5	1.04	9	8	1.03	13	2	1.10
4	6	1.03	9	9	1.03	13	3	1.10
4	7	1.03	9	10	1.03	13	4	1.10
4	8	1.03	9	11	1.03	13	5	1.10
4	9	1.03	10	0	1.04	13	6	1.11
4	10	1.02	10	1	1.04	13	7	1.11
4	11	1.02	10	2	1.04	13	8	1.11
5	0	1.02	10	3	1.04	13	9	1.11
5	1	1.02	10	4	1.04	13	10	1.11
5	2	1.01	10	5	1.04	13	11	1.11
						14	0	1.12

Table F-6. *Milking Shorthorn and Red Poll*

Age Yr.	Age Mo.	Factor	Age Yr.	Age Mo.	Factor	Age Yr.	Age Mo.	Factor
1	9	1.47	5	1	1.07	9	8	1.03
1	10	1.46	5	2	1.06	9	9	1.03
1	11	1.44	5	3	1.06	9	10	1.03
2	0	1.42	5	4	1.05	9	11	1.04
2	1	1.39	5	5	1.05	10	0	1.04
2	2	1.37	5	6	1.04	10	1	1.04
2	3	1.35	5	7	1.04	10	2	1.04
2	4	1.33	5	8	1.03	10	3	1.04
2	5	1.31	5	9	1.03	10	4	1.04
2	6	1.30	5	10	1.02	10	5	1.04
2	7	1.29	5	11	1.02	10	6	1.05
2	8	1.28	6	0	1.01	10	7	1.05
2	9	1.27	6	1	1.01	10	8	1.05
2	10	1.26	6	2	1.01	10	9	1.05
2	11	1.25	6	3	1.01	10	10	1.05

(continued)

Table F-6. (Continued)

Age Yr.	Age Mo.	Factor	Age Yr.	Age Mo.	Factor	Age Yr.	Age Mo.	Factor
3	0	1.24	6	4		10	11	1.05
3	1	1.23	to			11	0	1.06
3	2	1.22	7	9	1.00	11	1	1.06
3	3	1.21	7	10	1.01	11	2	1.06
3	4	1.20	7	11	1.01	11	3	1.06
3	5	1.19	8	0	1.01	11	4	1.06
3	6	1.18	8	1	1.01	11	5	1.06
3	7	1.17	8	2	1.01	11	6	1.07
3	8	1.16	8	3	1.01	11	7	1.07
3	9	1.15	8	4	1.01	11	8	1.07
3	10	1.14	8	5	1.01	11	9	1.07
3	11	1.14	8	6	1.01	11	10	1.07
4	0	1.13	8	7	1.02	11	11	1.07
4	1	1.13	8	8	1.02	12	0	1.08
4	2	1.12	8	9	1.02	12	1	1.08
4	3	1.12	8	10	1.02	12	2	1.08
4	4	1.11	8	11	1.02	12	3	1.08
4	5	1.11	9	0	1.02	12	4	1.08
4	6	1.10	9	1	1.02	12	5	1.08
4	7	1.10	9	2	1.02	12	6	1.09
4	8	1.09	9	3	1.03	12	7	1.09
4	9	1.09	9	4	1.03	12	8	1.09
4	10	1.08	9	5	1.03	12	9	1.09
4	11	1.08	9	6	1.03	12	10	1.09
5	0	1.07	9	7	1.03	12	11	1.09
						13	0	1.10

Table F-7. Mixed Breed

Age Yr.	Age Mo.	Factor	Age Yr.	Age Mo.	Factor	Age Yr.	Age Mo.	Factor
1	9	1.37	5	3	1.02	10	6	1.05
1	10	1.35	5	4	1.02	10	7	1.05
1	11	1.33	5	5	1.02	10	8	1.05
2	0	1.31	5	6	1.02	10	9	1.05
2	1	1.30	5	7	1.01	10	10	1.05
2	2	1.29	5	8	1.01	10	11	1.05

(continued)

Table F-7. (Continued)

Age Yr.	Age Mo	Factor	Age Yr.	Age Mo.	Factor	Age Yr.	Age Mo.	Factor
2	3	1.28	5	9	1.01	11	0	1.06
2	4	1.26	5	10	1.01	11	1	1.06
2	5	1.25	5	11	1.01	11	2	1.06
2	6	1.24	6	0		11	3	1.06
2	7	1.23	to			11	4	1.06
2	8	1.22	7	11	1.00	11	5	1.06
2	9	1.21	8	0	1.00	11	6	1.07
2	10	1.20	8	1	1.01	11	7	1.07
2	11	1.19	8	2	1.01	11	8	1.07
3	0	1.18	8	3	1.01	11	9	1.07
3	1	1.17	8	4	1.01	11	10	1.07
3	2	1.16	8	5	1.01	11	11	1.07
3	3	1.15	8	6	1.01	12	0	1.08
3	4	1.14	8	7	1.01	12	1	1.08
3	5	1.13	8	8	1.01	12	2	1.08
3	6	1.12	8	9	1.02	12	3	1.08
3	7	1.12	8	10	1.02	12	4	1.08
3	8	1.11	8	11	1.02	12	5	1.08
3	9	1.10	9	0	1.02	12	6	1.09
3	10	1.10	9	1	1.02	12	7	1.09
3	11	1.09	9	2	1.02	12	8	1.09
4	0	1.08	9	3	1.02	12	9	1.09
4	1	1.07	9	4	1.02	12	10	1.09
4	2	1.06	9	5	1.03	12	11	1.09
4	3	1.05	9	6	1.03	13	0	1.10
4	4	1.05	9	7	1.03	13	1	1.10
4	5	1.04	9	8	1.03	13	2	1.10
4	6	1.04	9	9	1.03	13	3	1.10
4	7	1.03	9	10	1.03	13	4	1.10
4	8	1.03	9	11	1.03	13	5	1.10
4	9	1.03	10	0	1.04	13	6	1.11
4	10	1.03	10	1	1.04	13	7	1.11
4	11	1.03	10	2	1.04	13	8	1.11
5	0	1.02	10	3	1.04	13	9	1.11
5	1	1.02	10	4	1.04	13	10	1.11
5	2	1.02	10	5	1.04	13	11	1.11
						14	0	1.12

G

NUMBER OF MILKINGS

FACTORS FOR REDUCING 305-DAY AGE CORRECTED RECORDS TO TWICE A DAY MILKING BASIS*

NOTE For additional information, see pages 56-7, 223 Age conversion factors are in Appendix F

	Factor for 3-Times-a-Day Milking			Factor for 4-Times-a-Day Milking		
Number of Days Milked	2 to 3 Years of Age	3 to 4 Years of Age	4 Years of Age and Over	2 to 3 Years of Age	3 to 4 Years of Age	4 Years of Age and Over
5 to 15	0.99	0.99	0.99	0.98	0.99	0.99
16 to 25	.98	.99	.99	.97	.98	.98
26 to 35	.98	.98	.98	.96	.97	.97
36 to 45	.97	.98	.98	.95	.96	.96
46 to 55	.97	.97	.97	.94	.95	.96
56 to 65	.96	.97	.97	.93	.94	.95
66 to 75	.95	.96	.96	.92	.93	.94
76 to 85	.95	.95	.96	.91	.92	.93
86 to 95	.94	.95	.96	.90	.91	.93
96 to 105	.94	.94	.95	.89	.91	.92
106 to 115	.93	.94	.95	.88	.90	.91
116 to 125	.92	.93	.94	.87	.89	.90
126 to 135	.92	.93	.94	.87	.88	.90
136 to 145	.91	.93	.93	.86	.88	.89
146 to 155	.91	.92	.93	.85	.87	.88
156 to 165	.90	.92	.93	.84	.86	.88
166 to 175	.90	.91	.92	.83	.85	.87
176 to 185	.89	.91	.92	.82	.85	.86
186 to 195	.89	.90	.91	.82	.84	.86
196 to 205	.88	.90	.91	.81	.83	.85
206 to 215	.88	.89	.90	.80	.83	.85
216 to 225	.87	.89	.90	.79	.82	.84
226 to 235	.87	.88	.90	.79	.81	.83
236 to 245	.86	.88	.89	.78	.81	.83
246 to 255	.86	.88	.89	.77	.80	.82

(continued)

Number of Days Milked	Factor for 3-Times-a-Day Milking			Factor for 3-Times-a-Day Milking		
	2 to 3 Years *of Age*	3 to 4 Years *of Age*	4 Years of Age *and Over*	2 to 3 Years *of Age*	3 to 4 Years *of Age*	4 Years of Age *and Over*
256 to 265	.85	.87	.88	.77	.79	.82
266 to 275	.85	.87	.88	.76	.79	.81
276 to 285	.84	.86	.88	.75	.78	.80
286 to 295	.84	.86	.87	.75	.78	.80
296 to 305	.83	.85	.87	.74	.77	.79

*Kendrick, J. F. (1955). "Standardizing Dairy Herd Improvement Association Records in Proving Sires," *Agr. Res. Service,* 52.1, Jan.

H AGE, WEIGHT, HEIGHT, AND CHEST GIRTH STANDARDS

Table H-1 Age, Weight, Height, and Chest Girth Standards for Growing Dairy Heifers

Age	Holstein Weight (lbs)	Holstein Height at Withers (in)	Holstein Chest Girth (in)	Ayrshire Weight (lbs)	Ayrshire Height at Withers (in)	Ayrshire Chest Girth (in)	Guernsey Weight (lbs)	Guernsey Height at Withers (in)	Guernsey Chest Girth (in)	Jersey Weight (lbs)	Jersey Height at Withers (in)	Jersey Chest Girth (in)
Birth	92	29.5	30.0	72	27.5	29.0	67	27.5	29.0	54	25.5	26.0
1st month	102	30.0	32.0	82	28.0	31.0	76	28.5	30.0	66	26.5	28.0
2nd month	138	32.0	35.0	114	30.5	35.0	98	30.0	33.0	92	29.0	31.0
3rd month	186	34.0	38.0	157	32.5	38.0	138	32.0	37.0	130	31.0	35.0
4th month	251	36.5	43.0	218	35.0	42.0	182	34.0	40.0	181	33.5	39.0
5th month	307	38.5	46.0	280	37.0	46.0	234	35.5	43.0	230	35.5	42.0
6th month	369	40.5	49.0	328	38.5	48.0	289	37.5	46.0	274	36.5	44.0
7th month	429	41.5	52.0	389	40.0	51.0	338	39.0	49.0	324	38.0	47.0
8th month	492	43.0	54.0	441	41.0	53.0	390	40.0	51.0	365	39.0	49.0
9th month	553	44.5	57.0	486	42.0	55.0	437	41.0	53.0	407	40.5	51.0
10th month	613	45.5	59.0	512	42.5	56.0	468	42.0	54.0	447	41.5	53.0
11th month	645	46.0	60.0	556	43.5	58.0	513	43.0	56.0	491	42.5	55.0
12th month	701	47.0	62.0	587	44.0	59.0	566	44.0	58.0	515	43.0	56.0
13th month, 14th month	762	48.0	64.0	643	45.0	61.0	592	44.5	59.0	560	43.5	58.0
15th month, 16th month	829	49.0	66.0	700	46.0	63.0	667	46.0	62.0	613	44.5	60.0
17th month, 18th month	898	50.0	68.0	754	47.0	65.0	727	46.5	64.0	667	45.5	62.0
19th month, 20th month	968	51.0	70.0	824	48.0	67.0	761	47.0	65.0	703	46.5	63.0
21st month, 22nd month	1044	52.0	72.0	871	48.5	68.0	827	48.0	67.0	763	48.0	65.0
23rd month, 24th month	1122	53.0	74.0	930	49.5	70.0	901	49.0	69.0	801	48.5	66.0

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Table H 2 Age, Weight, Height, and Chest Girth Standards for Growing Dairy Males

	Holstein			Ayrshire			Guernsey			Jersey		
Age	Weight (lbs)	Height at Withers (cm)	Chest Girth (cm)	Weight (lbs)	Height at Withers (cm)	Chest Girth (cm)	Weight (lbs)	Height at Withers (cm)	Chest Girth (cm)	Weight (lbs)	Height at Withers (cm)	Chest Girth (cm)
Birth	100	75 5	80 2	81	69 5	75 2	78	71 5	74 3	58	65 2	67 3
1st month	122	78 7	85 3	104	73 1	80 5	91	73 9	77 1	71	68 6	71 3
2nd month	167	84 0	92 7	128	75 5	84 6	117	77 1	83 3	99	72 9	78.1
3rd month	218	87 8	101 1	164	79 8	91 6	152	81 4	90 3	130	76 9	85 2
4th month	281	93 1	110 4	212	84 8	100 0	186	86 2	98 7	167	81 4	93 2
5th month	348	98 2	119 2	262	88 8	107 7	233	91 3	102 3	207	85 7	100 7
6th month	419	102 9	127 7	310	92 7	114 7	234	95 5	113 8	251	89 6	108 0
7th month	492	107 2	135 6	350	96 2	120 5	368	101 8	125 5	298	93 4	115 1
8th month	562	110 9	142 5	376	99 4	126 7	450	105 5	127 7	349	96 8	122 5
9th month	632	114 4	149 2	453	103 1	133 3				405	101 0	129 6
10th month	696	117 2	154 7	530	107 7	140 8				474	105 1	137 2
11th month	756	119 8	159 9	587	110 5	146 3				575	111.5	146 7
12th month	815	122.0	164 7	636	112 7	151 7				640	112 0	151 0
13th month	930	126 2	173 5	769	119 4	161 3						
14th month												
15th month 16th month	1050	130 2	183 0	885	126 0	171 0						
17th month 18th month	1159	133 6	192 2									
19th month 20th month	1278	137 5	199 4									
21st month 22nd month	1352	139 7	203 7									
23rd month 24th month	1410	142.0	206 8									

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